Field Guidebook No. 1

FIELD GUIDE TO GOLD OCCURRENCES IN NEW BRUNSWICK

by

A.A. Ruitenberg, S.R. McCutcheon, S.E. Watters,
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with contributions from:

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IN NEW BRUNSWICK

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ABSTRACT

Several types of epigenetic gold deposits have been found in New Brunswick. These deposits include quartz-carbonate veins and stockworks, polymetallic veins, contact metasomatic, porphyry-copper, and volcanic breccia (epithermal) deposits that are commonly localized in intensely deformed zones bounding tectonostratigraphic terranes. The gold deposits along the boundaries of the Avalon and St. Croix terranes in the south, and Miramichi and Elmtree terranes in the north, occur in dilatent structures related to dextral wrench faults, whereas the deposits along the southern margin of the Avalon Terrane occur in dilatent structures related to thrusting. Gold-bearing mineralizing fluids concentrated in these zones were probably generated by metamorphic dehydration of thickened lower crust during continental collision.

Descriptions of representative gold occurrences from the Alcida and Upsalquitch areas of northern New Brunswick, and the Bay of Fundy and South Oromocto Lake areas of southern New Brunswick are used to illustrate the various types of deposits.

RÉSUMÉ

Divers types de gisements aurifères épigénétiques ont été découverts au Nouveau-Brunswick. Ces gisements comprennent des filons de quartz-carbonate et des stockworks, des filons polymétalliques, des contacts métasomatiques, du minerai de cuivre porphyrique ainsi que des brèches volcaniques (épithermales) qui sont généralement localisés dans des zones très déformées en bordure de formations géologiques tectonostratigraphiques. Les gisements aurifères situés le long des frontières des formations géologiques Avalon et St. Croix au sud et des formations géologiques Miramichi et Elmtree au nord, se rencontrent sous forme de structures dilatantes reliées à des failles verticales de décrochement dextres, tandis que les gisements situés en bordure sud de la formation géologique Avalon se rencontrent sous forme de structures dilatantes reliées à des poussées. Les fluides minéralisateurs aurifères concentrés dans ces zones ont probablement été générés par une déshydratation métamorphique de l'écorce inférieure épaissie au cours de la collision continentale.

Des descriptions de gisements d'or représentatifs des régions d'Alcida et de l'Upsalquitch, au nord du Nouveau-Brunswick et des régions de la baie de Fundy et du lac South Oromocto, au sud de la province, ont été utilisées afin d'illustrer ces divers types de gisements.

GOLD METALLOGENY OF NEW BRUNSWICK

INTRODUCTION

Several types of gold mineralization can be distinguished in New Brunswick including auriferous stratiform volcanogenic deposits and several epigenetic types. The purpose of these field excursions is to examine epigenetic gold deposits and their relationship to the tectonic evolution of New Brunswick.

Stratiform types are associated with Ordovician and Precambrian volcanogenic base-metal sulphide deposits, respectively, in the northern Miramichi and Avalonian tectonostratigraphic terranes (Figure 1). The first significant primary gold production in New Brunswick was derived by cyanide heap leaching of gossan caps overlying the Ordovician Caribou and Heath Steele base-metal sulphide deposits in the early 1980's.

Many of the epigenetic deposits occur in dilatent structures associated with dextral wrench faults and conjugate thrusts that are particularly well developed along tectonostratigraphic terrane boundaries (Figure 1). They include auriferous quartz-carbonate and polymetallic veins, contact metasomatic and porphyry-copper deposits, and hydrothermal breccias. The quartz-carbonate veins and stockworks are the most abundant type. The polymetallic veins, contact metasomatic and porphyry-copper deposits commonly occur together and are genetically related. The occurrences associated with breccias display some of characteristics of epithermal deposits.

TECTONIC SETTING

The distinct relationship of gold deposits in New Brunswick to the faulted boundaries of major tectonostratigraphic terranes (Figure 1) is one of the principal guides for gold exploration in the Province (Ruitenberg and Davies 1986; Fyffe 1987). The terranes and cover sequences referred to in this paper are after Fyffe and Fricker (1987) and generally follow the boundaries of the tectonostratigraphic zones established by Ruitenberg et al. (1977). Fyffe and Fricker (1987) used stratigraphic evidence to designate each tectonostratigraphic zone as either a terrane or cover sequence. All of these major subdivisions are distinguished by contrasting lithofacies and structural styles. Terranes are fault-bounded, presumably allochthonous, and are considered to be emplaced by accretion to the continental margin. Cover sequences that overlap adjacent terranes constrain the time of terrane docking, but often obscure terrane boundaries.

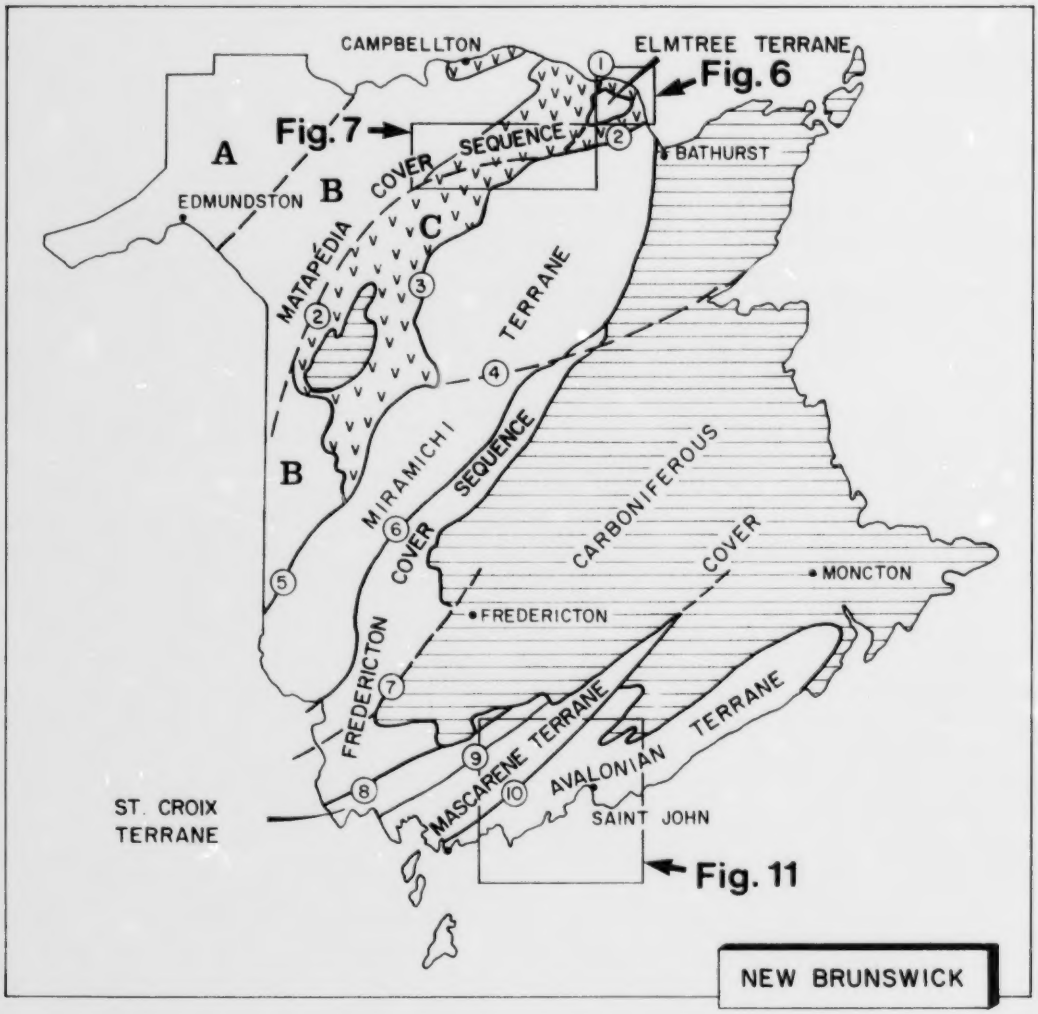


FIGURE 1. Tectonostratigraphic terranes and cover sequences of New Brunswick (modified after Fyffe and Fricker 1987), showing outline of Figures 6, 7, and 11. A = Edmundston Clastic Belt, B = Aroostook-Percé Carbonate Belt, and C = Tobique-Chaleur Volcanic Belt of the Matapédia Cover Sequence.

1. Jacquet River Fault
2. Rocky Brook-Millstream Fault
3. Portage Lakes-Serpentine River Fault
4. Catamaran Fault
5. Woodstock Fault
6. Bamford Brook-Hainesville Fault
7. Fredericton Fault
8. Basswood Ridge-Pendar Brook Fault
9. Ketchum Brook Fault
10. Belleisle Fault

The following terranes and cover sequences are referred to in this field guidebook: Matapédia Cover Sequence (subdivided into the Edmundston Clastic Belt, Aroostook-Percé Carbonate Belt, and Tobique-Chaleur Volcanic Belt); Elmtree Terrane, Miramichi Terrane, Fredericton Cover Sequence, St. Croix Terrane, Mascarene Terrane, and Avalonian Terrane (Figure 1). Detailed descriptions of the tectonostratigraphic subdivisions and their accretionary history are given in Ruitenberg et al. (1977) and Fyffe and Fricker (1987), respectively. Only a brief summary is presented here.

The Elmtree Terrane comprises the Early Ordovician Fournier Group and the conformably overlying Late Ordovician Elmtree Group. The Fournier Group is an ophiolitic complex mainly composed of intensely deformed gabbro that is enveloped by pillow basalts (Pajari et al. 1977; Rast and Stringer 1980). The Elmtree Group is characterized by intensely folded greywacke and slate. The Rocky Brook-Millstream dextral wrench fault has been used to define the boundary between the Elmtree and Miramichi terranes. Recent work by van Staal (1987) has shown, however, that thin slices of Elmtree Terrane have apparently been thrust over Miramichi Terrane by a series of southward-directed thrust faults associated with early folding. The Rocky Brook-Millstream Fault deforms and rotates the early penetrative tectonic fabric and, therefore, must post-date the major southward-directed thrusting. These structural relationships suggest that the Elmtree Terrane is a back-arc basin formed behind a volcanic arc. This arc is represented by the Ascot-Weedon Belt of the Eastern Townships in Quebec.

The Miramichi Terrane is comprised of intensely deformed Cambrian-Ordovician volcanic and sedimentary rocks of the Tetagouche Group. The lower Tetagouche Group is an interbedded assemblage of quartzite, quartz wacke, and phyllite, with a thin horizon of fossiliferous, Early Ordovician calcareous slate at the top. These rocks are overlain by a bimodal suite of Middle Ordovician rhyolitic and basaltic volcanic rocks with intercalated slate, chert, iron formation, and minor limestone (Helmstaedt 1971; Skinner 1974; Kennedy et al. 1979; Nowlan 1981; Fyffe 1982; Neuman 1984). Part of the western margin of the Miramichi Terrane in central New Brunswick is a migmatitic complex composed of sillimanite-bearing paragneiss, biotite schist, and amphibolite, which has been interpreted to represent Precambrian basement to the Tetagouche Group (Rast et al. 1976a; O'Brien 1977). Recent work by Fyffe et al. (1988) has demonstrated, however, that at least some of the amphibolites are high-grade metamorphic equivalents of the Tetagouche Group. Deformed granites of Middle Ordovician age within the Miramichi Terrane have been interpreted as plutonic equivalents of the felsic volcanic rocks (Bevier 1987; Whalen 1987). The lower Tetagouche rocks have been interpreted as a flysch apron developed off the northern, rifted margin of the Late Precambrian Avalonian Terrane (Rast et al. 1976a; Poole 1976;

Ruitenberg et al. 1977). The chemistry of the bimodal upper Tetagouche volcanic sequence (Davies et al. 1973, 1975, 1985; van Staal 1987) is consistent with a back-arc intracontinental volcanic sequence. Southward thrusting and folding associated with the closure of this basin during the Late Ordovician generated the penetrative fabric in these rocks.

Most of the Elmtree Terrane and the northwestern margin of the Miramichi Terrane are overlain by the Matapédia Cover Sequence. The Aroostook-Percé Carbonate Belt comprises the oldest rocks in this cover sequence. This belt contains Late Ordovician clastic turbidites of the Grog Brook Group, and conformably overlying Late Ordovician to Early Silurian limestone of the Matapédia Group (St. Peter 1978; Nowlan 1983; Malo 1988) (Figure 1). The Matapédia Group is conformably overlain by Early Silurian to Early Devonian sedimentary rocks to the northwest (Edmundston Clastic Belt) and by Early Silurian to Middle Devonian calcareous sedimentary and volcanic rocks to the southeast (Tobique-Chaleur Volcanic Belt).

To the north of the Rocky Brook-Millstream Fault, Silurian volcanic rocks of the Tobique-Chaleur Volcanic Belt are part of a shallowing-upward sequence (Chaleurs Group) that comprises in ascending order: thinly interbedded Early Silurian siltstone and fine-grained sandstone (Upsalquitch Formation), Middle Silurian nodular limestone (Limestone Point and La Vieille formations), volcanic boulder conglomerate (New Mills Formation), Late Silurian mafic volcanic rocks (Bryant Point Formation), and overlying felsic volcanic rocks (Benjamin Formation). The Chaleurs Group is conformably overlain by interbedded mafic volcanic rocks and grey calcareous siltstone of the Early Devonian Dalhousie Group (Greiner 1967; Lee and Noble 1977). Similar Devonian rocks to the south of the Rocky Brook-Millstream Fault have been assigned to the Tobique Group (St. Peter 1978). According to Dostal et al. (1989), volcanic rocks of the Tobique-Chaleur Volcanic Belt were extruded into strike-slip basins.

Conglomerate of the Chaleurs Group, which unconformably overlies Ordovician volcanic rocks along the northern margin of the Miramichi Terrane, forms a local base to the Matapédia Cover Sequence. Brachiopods from the conglomerate are Late Silurian (Ludlovian) in age (Helmstaedt 1971) and conodonts from overlying limestone are of Late Silurian (Pridolian) age (Nowlan 1988).

Along Chaleur Bay, the Chaleurs Group unconformably overlies Ordovician rocks of the Elmtree Terrane (Alcock 1935; Noble 1976; Fyffe and Noble 1985). The Chaleurs Group in this area includes, in ascending order: Early Silurian (Llandoverian) basal conglomerate (Armstrong Brook Formation); a Middle Silurian shelf sequence of calcareous sandstone and nodular limestone (Limestone Point and La Vieille formations); a clastic sequence of red, green, and grey siltstone, shale, and sandstone

possessing turbiditic features (Petit Rocher Formation); and Late Silurian (Pridolian) limestone-clast sedimentary breccias (LaPlante Formation). The latter two formations were deposited in a relatively deep basin lying between the Elmtree and Miramichi terranes.

The Cambrian(?) to Ordovician Cookson Group (Ruitenberg and Ludman 1978; Ludman 1987) of the St. Croix Terrane includes in ascending order: graphitic black slate (containing Early Ordovician graptolites) interbedded with minor pillow basalt; quartzofeldspathic wacke interbedded with laminated dark grey siltstone; and quartz arenite interbedded with black slate (containing Middle Ordovician graptolites). The Cookson Group is interpreted as a continental slope sedimentary sequence that was deposited on thinned continental crust (Ruitenberg et al. 1977).

The Cookson Group is unconformably overlapped by shallow-water Late Silurian conglomerate (Oak Bay Formation) and sandstone (Waweig Formation) in the south. To the north, the Cookson Group is separated from deep-water Silurian turbidites of the Fredericton Cover Sequence by the Basswood Ridge-Pendar Brook Fault. The turbidites comprise greyish green, thin-bedded, calcareous, flaggy sandstone, siltstone, and green to grey, generally pyritiferous slate of the Flume Ridge Formation.

The Fredericton Fault, a major wrench fault that cuts across Silurian turbidites of the Fredericton Cover Sequence, is considered to mark the subsurface boundary between the Miramichi and St. Croix terranes (Figure 1). Its extension into Maine (the Norumbega Fault), dextrally displaces Devonian granite. Thin thrust slices of high-grade metamorphic rocks in Maine and lower grade sedimentary rocks in New Brunswick, similar in lithology to the Tetagouche Group, outcrop south of the Fredericton Fault. A recent seismic survey across southern Maine (Stewart et al. 1986) indicates that southeastward-directed thrusting, involving Silurian-Early Devonian cover rocks, occurred prior to transcurrent movement along the Fredericton Fault (Fyffe 1988). This episode of thrusting probably coincided with the second deformation phase in this area (Ruitenberg 1967), which is characterized by southward-verging folds that deform the first penetrative fabrics in the Cookson Group and structurally overlying Silurian strata of the Flume Ridge Formation.

The Ketchum Brook Fault, a steep southeast-dipping structure that constitutes the boundary between the St. Croix and Mascarene terranes, is truncated by the Devonian Saint George granite batholith (McCutcheon and Ruitenberg 1987). Numerous mafic to felsic stocks and dykes were emplaced along the fault. Minor folds (similar to the third folds of Ruitenberg 1967), which deform the first penetrative fabric

(and second, where present) in the strata along the fault, possess a geometry consistent with east-northeast shortening and dextral wrench movement along the fault. Fracture patterns in the Saint George Batholith provide further support for this direction of shortening (McLeod et al. 1988).

A narrow belt of Silurian-Devonian volcanic and sedimentary rocks between the Ketchum Brook and Belleisle faults is referred to as the Mascarene Terrane (Figure 1). This belt is considered to be underlain by Avalonian basement in view of recent geological evidence. McCutcheon and Ruitenberg (1987), Currie (1988), and McLeod and Rast (1988) have identified Silurian sedimentary rocks unconformably overlying Hadrynian rocks along the northern margin of the adjacent Avalonian Terrane. In southeastern Maine, correlative Silurian-Devonian rocks unconformably overlie a poorly dated sequence of Precambrian-Early Palaeozoic rocks referred to as the Ellsworth Formation. The Ellsworth Formation is composed of volcanic and sedimentary rocks similar to the Eastern Volcanic Belt in the Avalonian Terrane of southern New Brunswick (Ruitenberg et al. 1979). The Ketchum Brook Fault, therefore, appears to mark the northwestern limit of Avalonian-type basement in the subsurface. Seismic evidence suggests that the equivalent Turtle Head Fault in Maine is a steep structure and penetrates the lower crust (Stewart et al. 1986).

The Belleisle Fault, including the Wheaton Brook splay, delimits the northwestern surface expression of the Avalonian Terrane. The oldest rocks in the Avalonian Terrane consist of intensely deformed calcareous and quartzitic metasediments of the Neohelikian Green Head Group. The Coldbrook Group, which unconformably overlies the Green Head Group, is composed of Hadrynian felsic and mafic volcanic rocks and intercalated metasedimentary rocks (Hayes and Howell 1937; Alcock 1938; Hofmann 1974). The bimodal Coldbrook volcanic sequence may be related to an intracratonic rift zone that immediately preceded opening of the Palaeozoic Iapetus Ocean (Giles and Ruitenberg 1977; McLeod 1987). An alternative model proposed by Rast et al. (1976b) suggests that the Coldbrook Group represents an ensialic arc along the margin of a microcontinent. Cambrian-Early Ordovician quartzite, sandstone, and pelitic metasediments of the Saint John Group and Late Devonian-Carboniferous fluviatile and deltaic sedimentary rocks overlie part of the Avalonian Terrane.

The Cambrian-Ordovician Meguma Terrane, which underlies southern Nova Scotia, was juxtaposed against the Avalonian Terrane during the Carboniferous (Rast and Grant 1973; Ruitenberg et al. 1973; Ruitenberg and McCutcheon 1982). The boundary is marked by the Cobequid-Chedabucto Fault Zone, which extends from the Cobequid Highlands of Nova Scotia westward under the Bay of Fundy. This fault is generally considered to be a

dextral wrench fault (Currie 1986; Nance 1986), but seismic evidence confirms that it becomes a northward-directed thrust along its eastern and western extensions (Hutchinson et al. 1988; Marillier et al. 1989). Along the Bay of Fundy coast, east and west of Saint John, the Precambrian and Carboniferous rocks of the Avalonian Terrane were intensely deformed during this thrusting event (Rast and Grant 1973; Ruitenberg et al. 1973; Currie and Nance 1983; Nance 1985).

RELATIONSHIP OF GOLD DEPOSITS TO TECTONIC EVOLUTION

Epigenetic gold mineralization in New Brunswick was generally controlled by an interplay between structural and magmatic events which took place during the latter stages of the Devonian Acadian Orogeny. Quartz-carbonate and polymetallic veins generally occur in ductile shear and brittle fracture zones associated with steep-dipping dextral wrench faults that separate various terranes. Emplacement of mafic-felsic intrusions was influenced by these major fault systems. Mineralization in the intrusions and associated contact metasomatic zones is concentrated in fracture zones that were at least in part generated by the intrusive activity (Ruitenberg and Fyffe 1982; Fyffe and Pronk 1985; Fyffe and MacLellan 1988; MacLellan and Taylor 1989). In contrast, epigenetic gold deposits along the Bay of Fundy coast (southern margin of the Avalonian Terrane) are associated with prominent thrust faults formed during the Permo-Carboniferous Hercynian Orogeny and show no relationship to a magmatic event.

Gold deposits occur in shear zones along the Rocky Brook-Millstream wrench-fault system, which separates the Elmtree and Miramichi terranes (Davies et al. 1969). Steep-plunging flexures or chevron folds, which were generated as a result of this shearing, post-date penetrative deformational fabrics. Evidence for thrust faults that pre-date these shear zones has been found in several areas. Van Staal (1987) suggested that slices of Elmtree Terrane have been superimposed on Miramichi Terrane by southward-directed thrusts that pre-date dextral strike-slip movement along the Rocky Brook-Millstream Fault. This Late Ordovician to Early Silurian thrusting event probably coincided with the closure of the back-arc basin (Fournier Group) by northward-directed underthrusting related either to crustal delamination and tectonic wedging (Stockmal et al. 1987) or to subduction (van Staal 1987). Isoclinal folding and layer-parallel shearing associated with the thrusting and subsequent tight folding generated the two penetrative fabrics in the Ordovician strata. The shear zones associated with the gold deposits deform and rotate these penetrative fabrics and a later cleavage associated with folding of the Matapédia Cover Sequence.

The Fredericton (Norumbega) Fault, which separates the Miramichi and St. Croix terranes and dextrally displaces Devonian granite, was also preceded by southward-directed

thrusting (Stewart et al. 1986; Fyffe 1988). These southward-directed thrusts emplaced slices of high-grade metamorphic rocks along the trace of the Norumbega Fault. Both Ordovician and Silurian strata are affected by this deformation. In the Rollingdam area of southwestern New Brunswick, southward-verging second folds that deform cleaved Ordovician and Silurian strata (Ruitenberg 1967) are consistent with southward-directed thrusting. The Honeydale Fault in this area post-dates second folds. Shear zones with associated chevron folds or flexures, which control emplacement of gold occurrences in the Rollingdam area, are associated with a third deformation that deformed two earlier fabrics (Ruitenberg 1967).

The structure of the gold-bearing zone along the southern margin of the Avalonian Terrane (north of the Cobequid-Chedabucto Fault) is dominated by northward- to northwestward-directed thrusts that were active during Carboniferous time (Rast and Grant 1973; Ruitenberg et al. 1973). A penetrative fabric roughly parallel to layering is associated with this early deformation. Gold deposits are associated with a later thrusting phase that deformed the early penetrative fabric (Watters 1988).

Extensive thrusting and associated folding along the terrane boundaries demonstrate that these zones were subjected to crustal thickening prior to emplacement of the epigenetic gold deposits. The gold deposits in the deformed boundary zones, except those along the Fundy coast, were emplaced in dilatent structures associated with east- to south-dipping, dextral wrench faults that were probably activated when the Avalonian, Mascarene, and St. Croix terranes were welded together. In contrast, gold deposits along the Bay of Fundy coast (southern margin of Avalonian Terrane) were emplaced in dilatent structures generated during a Carboniferous thrusting event.

Large volumes of mafic and felsic magma were generated between the Late Silurian and Middle Devonian as a result of this crustal thickening process (Fyffe et al. 1981). The variations in structural style and mineralogy within the area north of, and along the northern margin of the Avalonian Terrane, appear to be related to the level of emplacement and proximity to mafic and felsic intrusions. Auriferous poly-metallic veins and contact metasomatic deposits are undoubtedly related to relatively deep-seated intrusions. The auriferous quartz-carbonate veins associated with ductile shear and brittle fracture zones are also deep seated, but are not always associated with intrusions. The auriferous porphyry-copper deposits have characteristics of shallow-emplaced intrusions. The sub-volcanic epithermal deposits formed near surface by hot-spring activity (Burton 1987). The auriferous deposits along the Bay of Fundy coast are different in that they are related to

conjugate thrusts and exhibit no obvious relationship with intrusive activity. They also differ by having a low content of arsenopyrite, bismuthinite, and stibnite in contrast to most deposits in the deformed zones to the north. Despite their great variety, the epigenetic deposits in New Brunswick are all associated with extensive carbonatization and silicification.

Several authors have discussed the relationship of gold deposits to thrust and strike-slip faults. Fyfe (1986) emphasized how large quantities of high-temperature, CO_2-rich, and low-salinity fluids capable of leaching and transporting gold can be generated as a result of metamorphic dewatering produced by overriding of crustal blocks. Fluids rising from basement beneath thrusts tend to produce hydraulic fracturing, which may drain large volumes of underplated rock. As a result, fluids move out in front of the thrust, along the thrust surface, or penetrate the overthrust. Sibson et al. (1988) suggest that seismogenic fault failure creates fracture permeability within the rupture zone, allowing sudden draining of the geopressurized reservoir at depths. Hydrothermal self-sealing leads to reaccumulation of the fluid pressure, and the process is repeated.

Cameron (1988) relates the genesis of Archaean gold deposits to crustal thickening. He suggests that upward streaming of mantle-derived CO_2 along shear zones in the lower crust is one means for dehydrating amphibolite to granulite. This process is accompanied by the removal of lithophile elements to higher crustal levels. Gold is probably dissolved by CO_2-rich fluids from the sulphide phase of rocks in which it is almost invariably present. Glasney (1983) showed replacement of sulphide by magnetite by the reaction: $2CO_2 + 3FeS_2 = Fe_3O_4 + 6S$. The sulphur is removed in the fluid phase and may further enhance the mobilization of Au, together with As and Sb, because these elements form soluble sulphur complexes (Seward 1973; Boyle and Jonasson 1984). After dissolution, gold can migrate from the lower crust by two possible mechanisms (Cameron 1988): (1) a CO_2-rich fluid containing Au is dissolved in partial melts generated as a result of water released during dehydration and is exsolved as these melts rise; sulphur and elements complexed by sulphur will partition into the CO_2-rich phase, which, because of its lower density, will rise above the melt (Holloway 1976); (2) a large influx of CO_2 exceeds the capacity of the melt to dissolve it, so that a mineralized CO_2-rich vapour rises independent of the melt. These hypotheses can account, respectively, for the typical intrusion-related deposits and those that are strictly structurally controlled. Another hypothesis (Rock and Groves 1988) suggests lamprophyres as transporting agents for gold. As these magmas rise, they interact with crustal rocks generating felsic magmas and releasing their gold in metamorphic hydrothermal systems.

SUMMARY

Terrane accretion, beginning in the Late Ordovician, thickened the crust and consequently generated large volumes of mafic and felsic magmas. Emplacement of these magmas was tectonically controlled and took place mainly between the Late Silurian and Early Devonian and to a lesser extent between the Middle Devonian and Early Carboniferous.

Epigenetic auriferous deposits in New Brunswick tend to be localized along contacts of intrusions and in major fault zones that mark terrane boundaries. Gold in these deposits was probably scavenged from the lower crust during metamorphic dehydration reactions that were enhanced by the release of CO_2-rich fluids from the mantle. The auriferous fluids were dissolved in, and transported by crustal melts, as well as by mantle-derived mafic magmas, and subsequently released at various levels in the crust. Gold-bearing carbonate veins localized in Carboniferous thrust zones are devoid of associated igneous rocks suggesting that late faults channeled metamorphic fluids directly from the lower crust.

GOLD OCCURRENCES IN NORTHERN NEW BRUNSWICK

This part of the field guide describes gold occurrences situated in the Tobique-Chaleur Volcanic Belt of the Matapédia Cover Sequence and the Elmtree Terrane (Figure 1). Field stops are shown on Figures 6 and 7, the outline of which is indicated on Figure 1.

GOLD MINERALIZATION AND ALTERATION

At least three types of gold mineralization can be recognized depending upon rock type, structural control, and level of emplacement. One type formed relatively deep in the crust, and is hosted by dykes or brecciated metasedimentary rocks adjacent to these intrusions. Another type formed at relatively shallow depth, has classic epithermal characteristics, and may also be intrusion related. The third type exhibits strong structural control, and the gold-bearing fluids may be of metamorphic rather than magmatic origin. Intermediate types exist, and there is a good possibility for skarn-type deposits as well (Figure 2). The style of alteration differs with each type.

Intrusions are abundant, particularly in the Silurian and older rocks of the Aroostook-Percé Carbonate Belt. Work by Philpott (1989) shows that most of them have mafic to intermediate compositions (45-68% SiO_2), but some of the larger ones are felsic (73-78% SiO_2). Many are feldspar porphyritic; a few contain quartz phenocrysts. Dykes generally parallel cleavage, and a few actually possess a poorly developed cleavage. These intrusions are considered to be syn- to post-tectonic, and largely comagmatic with the Silurian-Devonian volcanic pile.

Many auriferous intrusions are spatially associated with brecciated and iron-carbonate altered sedimentary rocks with abundant pyrite. Some intrusions have pervasive alteration whereas others are only slightly altered, even though they may be in contact with highly altered country rocks. Scattered quartz-carbonate veins and/or stockworks cutting these altered intrusions have yielded assays up to 15 g/t Au (Table 1).

The intrusions are considered to be the source of the hydrothermal fluids that caused the alteration because of their close spatial association. Also, there are major faults that clearly cut and overprint the alteration. As the intrusions (magmas) rose through the crust, it is postulated that a CO_2-rich volatile phase evolved from them (perhaps due to adiabatic decompression), collected in cupolas, and caused brecciation and alteration of the deformed metasedimentary rocks above these cupolas (Stage 1, Figure 3). Magma bodies that "stuck" at a particular level produced additional volatiles by inward cooling, and these volatiles caused fracturing and alteration

TABLE 1

MAXIMUM CONCENTRATION OF GOLD OBTAINED IN GRAB SAMPLES

FROM THE OCCURRENCES
(after Pronk and Burton 1988)

1.	Upsalquitch Forks	10 345 ppb
2.	Simpsons Field	8069 ppb
3.	Mulligan Gulch	1724 ppb
4.	Dalhousie Road	10 345 ppb
5.	McCormack Brook	10 690 ppb
6.	McCormack Brook East	14 826 ppb
7.	Jonpol	15 172 ppb
8.	Southeast Upsalquitch River	1448 ppb
9.	Rocky Brook	5700 ppb

Refer to Figure 8 for location of first eight gold occurrences.

of their own outer cooled rim (stage 2a, Figure 3). Alternatively, parts of magma bodies (dykes) that rose to higher crustal levels may have cross-cut the alteration envelope of their parent intrusion (stage 2b, Figure 3).

Epithermal deposits are characterized by argillic and hematitic alteration, brecciation, and multi-stage quartz veining. The veins mainly consist of vuggy and chalcedonic quartz and they cross-cut stratigraphy, as well as structure, in penetratively deformed rocks. Manganese oxides and purple fluorite are common in the veins that are geochemically anomalous in mercury. The altered host rocks are generally elevated in antimony, silver, arsenic, and base metals (Burton 1987). At Rocky Brook, there is evidence of some lateral fluid flow along permeable tuff and/or epiclastic beds, i.e., stratiform alteration.

Several "geochemical occurrences" of gold, as well as local "Rocky Brook-type" epithermal alteration zones, have been reported within the Tobique-Chaleur Volcanic Belt farther to the southwest in the Riley Brook area (Wilson 1988). Prior to 1988, exploration in this area was sporadic and for the most part focussed on base metals (i.e., the Mount Costigan deposit). Recently, several prospects yielding gold and pathfinder-element lithogeochemical anomalies have been explored for their gold potential. At Shingle Gulch, Sewell Brook, and Riley Lake, pyrite-sphalerite-galena ($\pm$ chalcopyrite) mineralization is associated with hydrothermally altered felsic volcanic rocks locally displaying brecciation, hematitization, intense leaching, silicification, or sericitization. Maximum values for gold at these showings are 120, 170, and 40 ppb, respectively. West of Bald Peak and along Riley Brook,

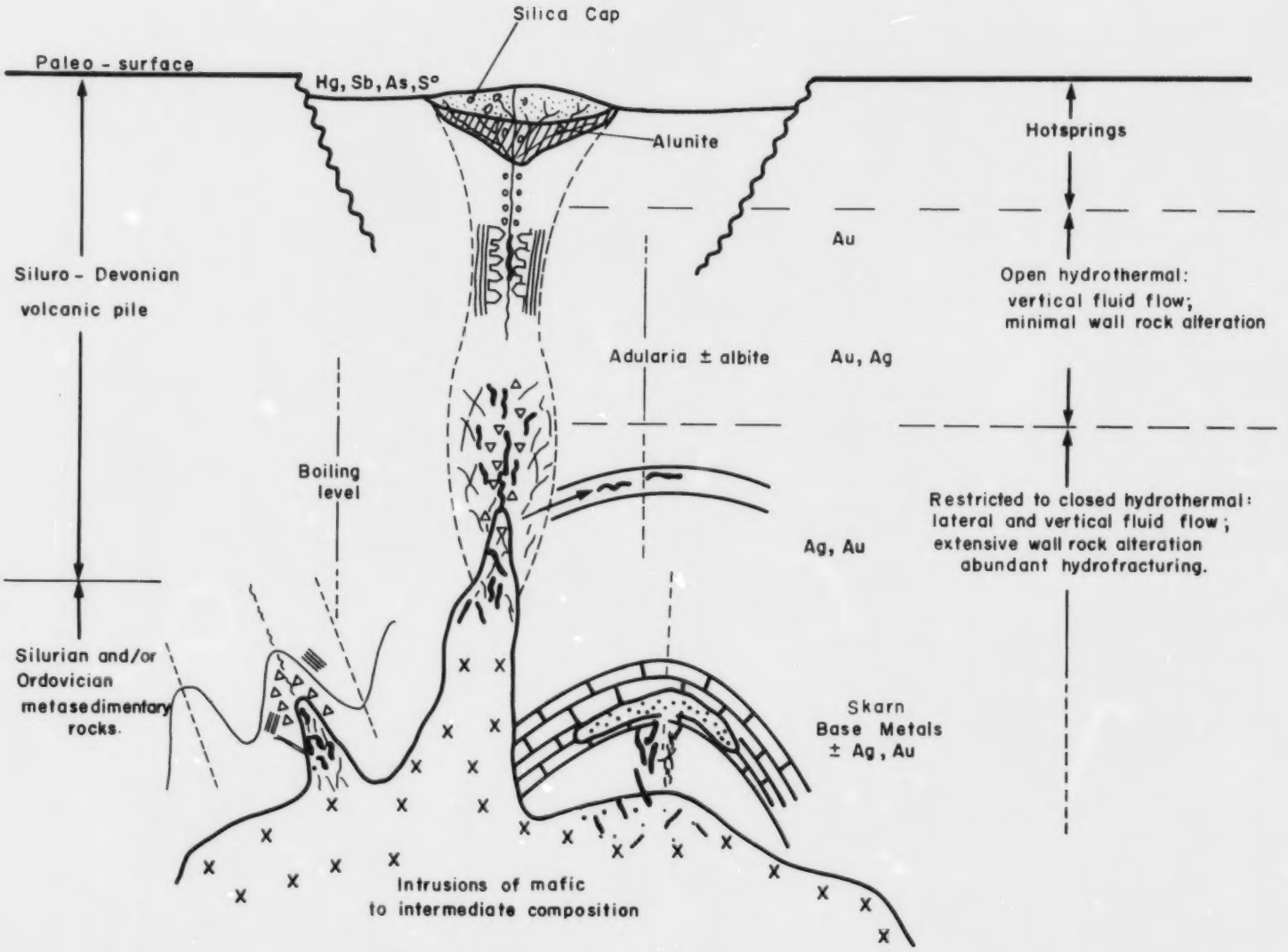


FIGURE 2. Diagrammatic section showing inferred deposit characteristics with respect to depth below the palaeosurface. Modified after Panteleyev (1986).

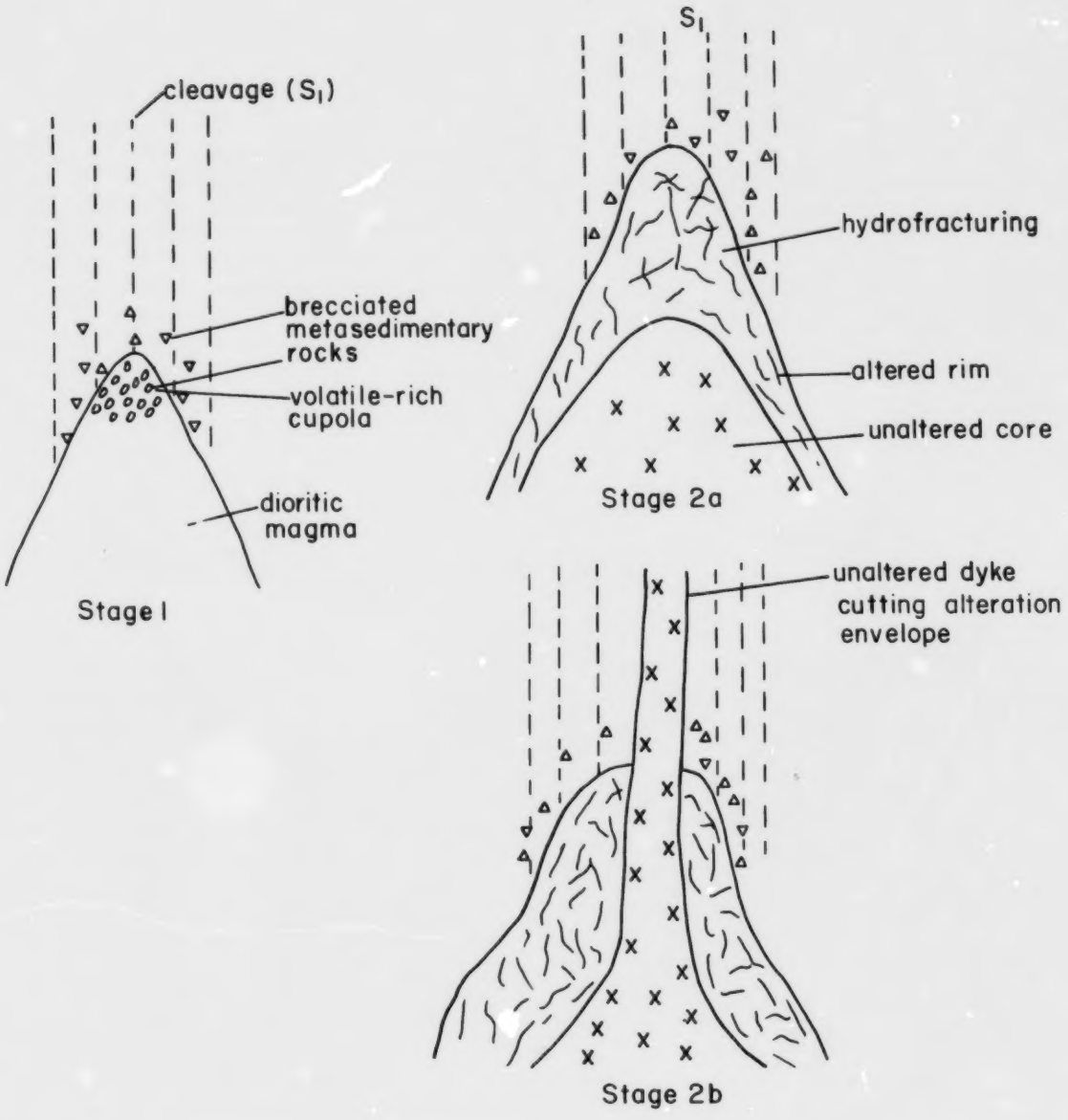


FIGURE 3. Cartoons illustrating how intrusion-associated iron-carbonate alteration may have developed.

intensely leached, fractured, and hematitized siltstones and mafic volcanic rocks are macroscopically identical to some of the altered rocks at the Rocky Brook occurrence although precious-metal values in samples assayed to date have been low.

Structurally-controlled deposits have alteration assemblages that are, in part, determined by the composition of their host rocks. For example, the gabbro at the Elmtree deposit exhibits intense saussuritization, chloritization, and carbonatization in shear zones because of its original mineralogy. However, external components have also been added because the rocks exhibit effects of albitization and silicification, are cut by quartz veins, and are highly enriched in arsenic.

THE ELMTREE DEPOSIT (West Gabbro Zone)

In 1984, a grass-roots-prospecting program was carried out in the Alcida area as a follow-up to stream-sediment anomalies. This resulted in the discovery of precious-metal mineralization on the Elmtree property that fall. Prospecting in the vicinity of anomalous As and Sb sites discovered semi-massive sulphide-quartz veins carrying Au values up to .50 oz./ton (17.5 g/t) and Ag values up to 16.00 oz./ton (555 g/t) along South Branch Elmtree River. Subsequent prospecting and staking of the Discovery Zone located the West Gabbro Zone some 2000 feet away along the trend of a favourable structure (Hoy 1987).

Since then, a significant amount of exploration work has been carried out, including ground geophysical and geochemical surveys, geological mapping, and 35 000 feet of diamond drilling, mainly on the West Gabbro Zone.

The purpose of this synopsis is to summarize the geological setting, alteration styles, and mineralization of the Elmtree deposit, in particular the West Gabbro Zone.

Geological Setting:

The northern part of the claim group in the Alcida area (Plate 89-9A) is underlain by a thick sequence of intercalated graphitic argillites, phyllites, slates, and greywackes of the Ordovician Elmtree Group with local interbeds of coarse grit and pebble conglomerate. The Elmtree Group is in fault contact with a thick sequence of calcareous metasediments of the Silurian Chaleurs Group. Lithologies within the Chaleurs Group include greenish grey siltstone, argillite, sandstone, pebble to cobble conglomerate, and minor limestone. These rocks generally underlie the southern part of the claim group. Locally, intrusive rocks cut the above sequences and include mafic to felsic stocks, sills, and dykes of diabase, gabbro, granite, feldspar porphyry, and felsite. Skarn is developed within the contact metamorphic aureoles of these intrusive rocks.

Structurally, the most important feature on the claim group is the Elmtree Fault, a wrench fault, of probable regional extent. The fault is a broad zone of intense shearing, fracturing, and deformation, which separates graphitic argillites of the Elmtree Group from calcareous siltstones of the Chaleurs Group. Almost all mineralization discovered to date on the property has been intimately associated with the fault zone or with parallel and en echelon splays from it.

Geology of the Deposit:

The West Gabbro Zone consists of a hydrothermally altered and strongly deformed Ordovician(?) gabbroic sill, bounded by graphitic argillites and hornfels of the Elmtree Group. The sill has been intermittently traced along a strike length of 1500 feet, and ranges in width from 10 to 125 feet. Dips are largely vertical near the surface, but dip northerly at depth (Plate 89-9B).

The sill is characterized by fine- to medium-grained ophitic margins, gradational into a medium- to coarse-grained core. Compositionally, the margins are characterized by equigranular subophitic to ophitic gabbro, whereas the cores are gabbroic anorthosite to anorthosite (Figure 4). These coarser grained, fractionated phases have been termed cumulates, due to the clustering of plagioclase apparent within them. Ductile and brittle deformation are locally very intense within the sill (Paktunc 1987; Murck 1986).

Alteration and Mineralogy:

The alteration of the gabbros consists of saussuritization of plagioclase, associated with chloritization of ferromagnesium minerals. Within highly deformed gabbro, a microcrystalline alteration assemblage of carbonate, quartz, chlorite, albite, and sericite forms a matrix interstitial to plagioclase and mafic mineral remnants. This alteration assemblage is also commonly seen in several generations of veining.

Higher gold values are associated with sulphide-rich zones cutting the coarse-grained gabbro. The best zones of sulphide mineralization are closely associated with intensive zones of silica flooding and are proximal to the margins of quartz veins. Within these silica-rich zones, combined sulphide abundance is as high as 25%. The opaque minerals consist of varying amounts of arsenopyrite, pyrrhotite, and pyrite with minor chalcopyrite, stibnite, and sphalerite. Scanning electron microscopy indicates that gold occurs as free grains, generally less than 10 microns in size. The gold is commonly attached to pyrrhotite that occurs as fracture fillings in pyrite, arsenopyrite, and pyrrhotite, and rarely as inclusions within arsenopyrite (Harris 1986).

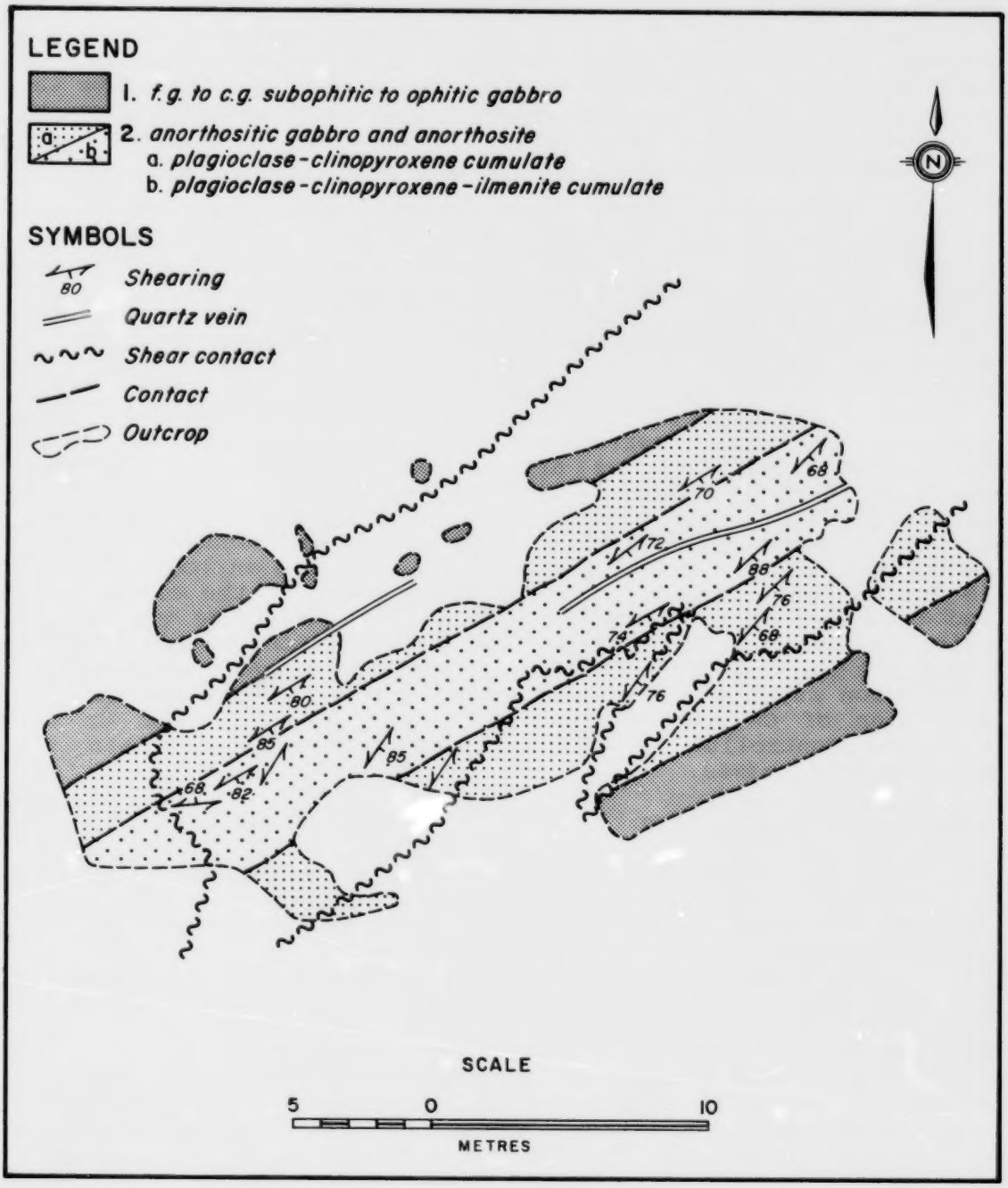


FIGURE 4. Detailed geology of Trench 3 in the West Gabbro Zone.

Geochemistry:

The geochemistry of mineralized and unmineralized gabbro was studied by systematically analysing drill-core pulps from a section through the central part of the sill. The objective was to determine the variations in major and trace elements throughout the sill, and compare these to observed mineralogical and alteration changes (Figures 5a and 5b).

The auriferous zone, comprising coarse-grained, highly altered anorthositic gabbro, assays 0.167 oz./ton (6 g/t) Au across 36.0 feet. The border phases flanking the auriferous zones consist of moderately to strongly altered, fine- to medium-grained gabbro. Both upper and lower intrusive contacts are characterized by the development of cherty hornfels in the enclosing sediments.

Upon inspection of the data, it is evident that arsenic is strongly, positively correlated with the auriferous zone. This is hardly surprising, as arsenopyrite is the most abundant sulphide in gold-bearing zones. Moderate, positive correlation of Si, Fe, and Na are also evident. Within gold-bearing zones, secondary quartz and albite form major constituents of the microcrystalline alteration assemblage, and the enrichment of Fe is due to the abundance of sulphides. However, the elements Mg and Ca show moderate negative correlation with the gold zone, which is somewhat surprising given the presence of sericite and carbonate as alteration products. Although hydrothermal alteration may have affected these elements to some extent, the depletion of Ca and Mg together with V, Co, Ni, and Cr was probably controlled by differentiation processes within the anorthositic phases.

Summary and Conclusions:

1) Gold at Elmtree is structurally controlled, and is intimately related to the trend of the Elmtree Fault.
2) The auriferous zone is hosted within a strongly deformed and hydrothermally altered gabbroic sill.
3) The main alteration consists of saussurite and chlorite with associated carbonate, quartz, chlorite, sericite, and albite as microcrystalline alteration products.
4) Geochemical studies suggest that the elements As, Si, Na, and Fe are moderately to strongly enriched within the gold zone. The distribution of these elements is controlled by hydrothermal alteration and sulphidization. Depletion of Ca, Mg, V, Ni, and Cr within the gold zone is controlled by differentiation processes.
5) Gold occurs as free grains, generally less than 10 microns, attached to pyrrhotite, healing microfractures in arsenopyrite, pyrite, and pyrrhotite, and occasionally as inclusions within arsenopyrite.

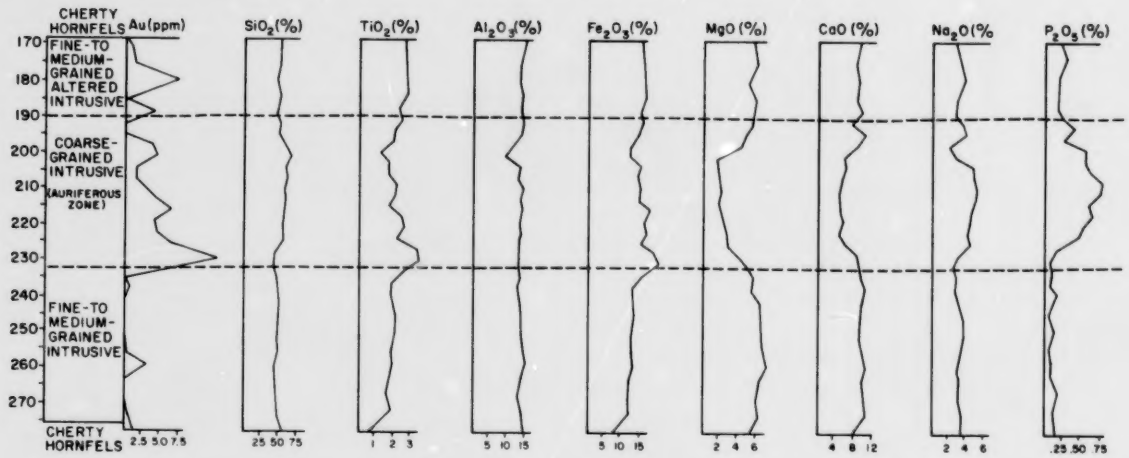


FIGURE 5a. Major-element variation in hole ME-85-4 (located on Line 4 + 70 W; bearing 330°, inclination 60°).

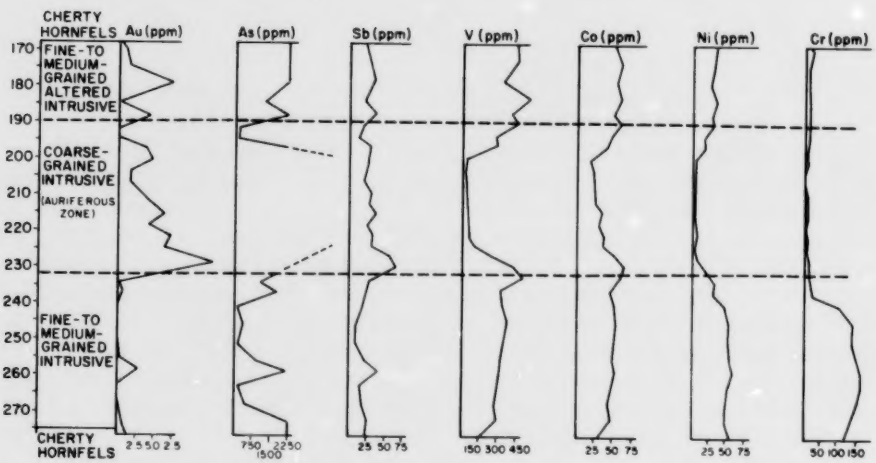


FIGURE 5b. Trace-element variation in hole ME-85-4.

STOP DESCRIPTIONS FOR THE ALCIDA AREA

Field stops are located on Figure 6, the outline of which is indicated on Figure 1.

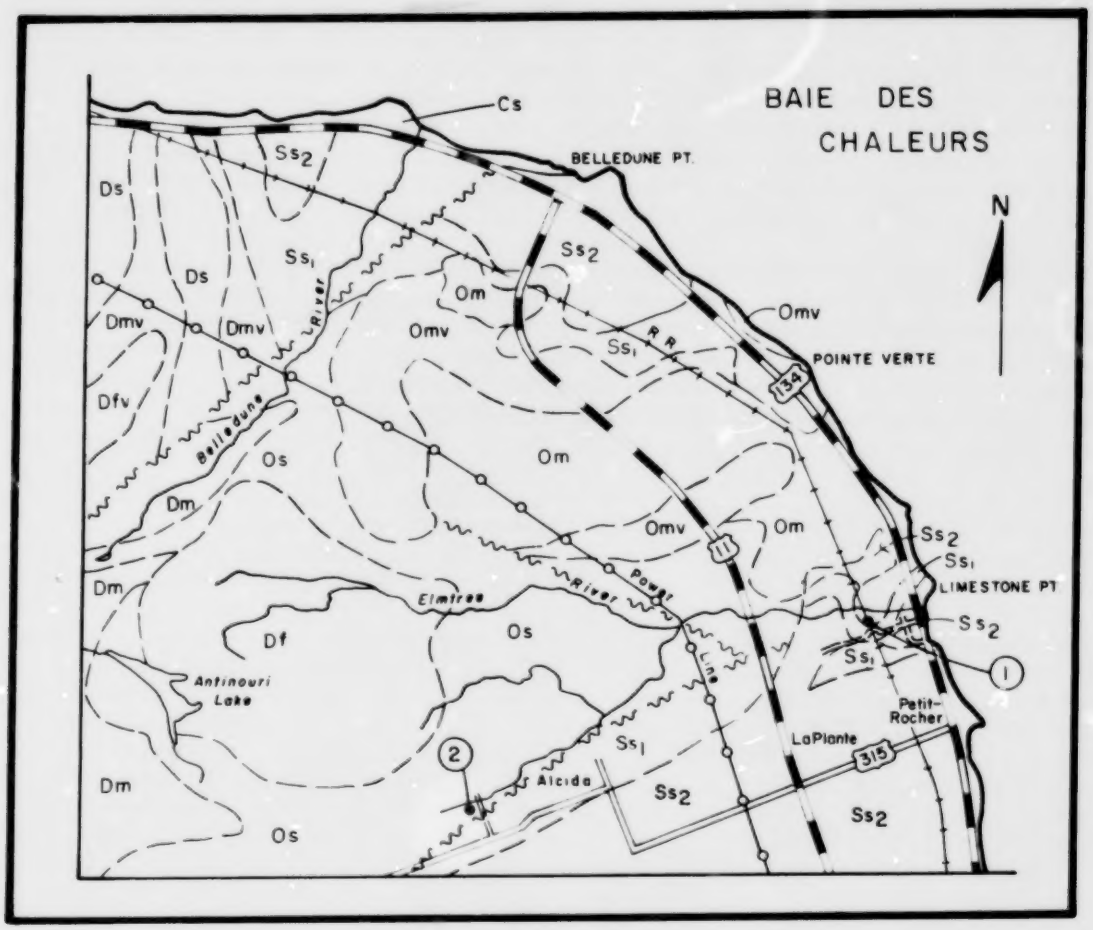
Kilometres

C*	D**	
0		Start of road log, intersection of Highways 11 and 315. Exit east onto Highway 315, and travel to Highway 134.
4.1	4.1	Intersection of Highways 315 and 134. Turn north onto Highway 134.
6.8	2.7	Turn left on Étang du nord Road.
7.1	0.3	Intersection. Continue straight.
8.0	0.9	Stop 1.

* C = cumulative distance in km
** D = distance between each point in km

STOP 1. Elmtree River Railcut. Metabasites of the Devereaux Formation, the lowest member of the Ordovician Fournier Group, are exposed along the railway for about 1 km. Diabasic and gabbroic dykes of variable thickness intrude phyric to aphanitic mafic flows and/or high-level intrusions. Possible relict pillows and amygdaloidal basalts can be seen in the more southerly outcrop. Medium- to coarse-grained gabbro with well-developed cumulate textures becomes progressively more abundant to the north of the Elmtree River indicating deeper levels of intrusion. This section is interpreted as a section of oceanic crust transitional between layer 3 cumulate gabbros and layer 2 dykes and flows.

C*	D**	
0		Return to Exit 326 at Highway 11. Reset road log to zero. Proceed westward on Highway 315.
0.5	0.5	LaPlante 4-way intersection; continue westward.
4.2	3.7	T-intersection. Turn right to Alcida.
5.8	1.6	Turn left.
8.2	2.4	Stop and park at the entrance to the access road (Plate 89-9A). With the permission of Corona Corporation in Bathurst and the landowner, you may walk in on this road to the north about 650 m. Turn and walk westward about 540 feet (165 m) to Stop 2A. From here, walk about 130 feet (40 m) southward, then about 540 feet (165 m) westward on side road to Trenches #16 and #17 (Stop 2B). Stops 2A and 2B are located on the property map (Plate 89-9A), near Lines 22 W and 28 W, respectively.



LEGEND

CARBONIFEROUS
Cs sedimentary rocks

DEVONIAN
Df granite
Dm diabase, gabbro
Dfv felsic volcanic rocks
Dmv mafic volcanic rocks
Ds sedimentary rocks

SILURIAN
Ss_2 calcareous siltstone, limestone, shale, sandstone; minor conglomerate

Ss_1 conglomerate, minor shale and limestone

ORDOVICIAN
Om gabbro
Omv pillow basalt (Fournier Grp)

Os phyllite and greywacke (Elmtree Group)

FIGURE 6. Geology of Pointe Verte (NTS 21 P/13) map area showing field stops near Alcida.

STOP 2A. Elmtree Trench #14. This stop is located near Line 22 W (Plate 89-9A). The trenched area exposes oxidized coarse-grained plagioclase cumulates (anorthositic gabbros) in contact with medium-grained ophitic gabbro (border phases). Farther down the hill toward the brook are sporadic subcroppings of black argillite of the Elmtree Group (enclosing sediments). Channel samples taken across the trench assayed 8 g/t Au over 9 m.

STOP 2B. Elmtree Trenches #16 and #17. Stop 2B is near Line 28 W (Plate 89-9A). These trenches expose altered, sheared, and fractured plagioclase-clinopyroxene cumulates (anorthositic gabbro) with ophitic to sub-ophitic, fine- to medium-grained gabbro forming the margins. Quartz veins have healed shear and fracture zones in places. A 9 m channel sample cut across the trench assayed 4.7 g/t Au.

UPSALQUITCH-JACQUET RIVER SHOWINGS

The Upsalquitch-Jacquet River area (Figure 7) is accessible via the Road to Resources from Bathurst and the NBIP (New Brunswick International Paper) Road from Campbellton. Prior to the gold discovery near Simpsons Field by prospector Michael Smith in the fall of 1984, the only known gold in the area occurred in association with massive sulphide deposits hosted by the Ordovician Tetagouche Group. Subsequently, several other gold occurrences have been found, returning assays ranging from 1.4 to 15.2 g/t (Table 1). Many similarities are apparent between these showings, but there are minor differences in the style of mineralization and nature of alteration. Most of the discoveries are proximal to intrusions that may have been emplaced along splays of the Rocky Brook-Millstream Fault (Pronk and Burton 1988).

Geological Setting:

Highly deformed Cambrian-Ordovician rocks of the Miramichi Terrane (Tetagouche Group) are found in the southeastern part of the Upsalquitch-Jacquet River area (Figure 7). Silurian-Devonian rocks of the Tobique-Chaleur Volcanic Belt, which contain all of the recently discovered gold occurrences, are divisible into two groups. The Tobique Group to the south of the Rocky Brook-Millstream Fault is dominated by sedimentary rocks with minor volcanics in the west. The Chaleurs and Dalhousie groups, occurring to the north of the fault, contain abundant volcanic rocks. Upper Ordovician to Lower Silurian sedimentary rocks of the Aroostook-Percé Carbonate Belt occupy the northwestern part of the area. Many small- to intermediate-sized mafic and felsic intrusions cut the supracrustal rocks.

Mineralization and Alteration:

Different styles of gold mineralization largely reflect the level of intrusion emplacement and/or the distance from the contact of the intrusions in the stratigraphic pile. Three broad subdivisions are recognized: 1) volcanic-hosted, 2) intrusion-hosted, and 3) skarn-type.

1. The Rocky Brook showing (Stop 15; Figure 7) occurs within the volcanic pile of the Chaleurs Group. However, interbedded sedimentary rocks, which comprise only a minor part of the total section, actually host the mineralization. Cross-cutting, northwest-dipping fractures with associated silicification and brecciation have yielded up to 5200 ppb Au and 921 ppm Ag. The fracture zones may be associated with a felsic intrusion at depth, because there is a large gravity anomaly in this area. Similar showings occur in the Riley Brook area to the southwest, but are not included as field stops.

2. Intrusion-hosted systems, common in Silurian and Lower Devonian sedimentary rocks in the south-central part of the Upsalquitch area, comprise three varieties:

a. Auriferous mafic intrusions and associated breccias (e.g., Stops 3 and 7) - The mineralization is associated with intense carbonatization and abundant quartz-siderite veining. Diamond drilling has indicated alteration zones over 200 m thick with assay values as high as 15 000 ppb Au.

b. Auriferous felsic intrusions (e.g., Stop 8) - Altered feldspar porphyry and minor quartz-feldspar porphyry exhibit the same alteration as the mafic intrusions, but are much less widespread. Recorded gold values are in the 200-1000 ppb range. Relatively large felsic intrusions are common in the northern part of the area in the Aroostook-Percé Carbonate Belt. Grab samples indicate that some of these are geochemically anomalous in gold (10-40 ppb), but no spatial association is apparent between till-geochemical anomalies (Pronk and Burton 1988) and these intrusions.

c. Polymetallic auriferous veins in mafic intrusions, which lack pervasive iron-carbonate alteration (e.g., Stop 11) - The only known occurrence of this type is associated with an altered diorite that lies near the eastern edge of the Aroostook-Percé Carbonate Belt. The quartz-calcite veins carry up to 10 350 ppb Au and 350 ppm Ag.

3. Skarn-type systems are present in the northwestern part of the area (McKenzie Gulch and Popelogan deposits; Davies 1979), where intrusions cut calcareous rocks of the Matapédia Group. The intrusions and their associated skarns have not been systematically tested for gold, but geochemically anomalous values have been obtained from grab samples.

STOP DESCRIPTIONS FOR THE UPSALQUITCH-JACQUET RIVER AREA

Field stops are located on Figure 7, the outline of which is indicated on Figure 1.

Kilometres

C*	D**	
0		Depart westward on the "Road to Resources" (Highway 180) from Exit 310 at the Atlantic Host Motel, Bathurst.
61.8	61.8	Stop 1.

STOP 1. Eighteen Mile Brook road cut. This stop exhibits unaltered Silurian rocks at the southern margin of the Matapédia Cover Sequence. Greenish grey, thin-bedded sandstone and siltstone dominate the outcrop along the southeast side of the road. At the east end of this outcrop, unbedded sedimentary breccia fills a channel cut into these rocks. The same type of breccia dominates the outcrop on the northwest side of the road. It contains abundant limestone clasts that have Late Silurian (Ludlovian) fossils (Helmstaedt 1971). Subtle changes in the attitude of primary layering result from open folds that have axial planes subparallel to the road.

The next outcrops to the west are stratigraphically lower and consist of red sandstones and grits with a cobble conglomerate at the base of the section. This conglomerate contains mafic volcanic and gabbro clasts from the underlying Tetagouche Group. Some of these clasts were polydeformed prior to being incorporated in the conglomerate.

C*	D**	
		Continue driving westward.
71.1	9.3	Turn right (north) on NBIP Road to Dalhousie.
73.2	2.1	Stop 2.

STOP 2. Ramsay Brook borrow pit. The Silurian sedimentary rocks at this stop represent a fine-grained (basinward) facies of the coarse-grained rocks seen at Stop 1. The borrow pit on the east side of the road contains dark grey, thin-bedded siltstone. The rocks are folded and have a well-developed slaty cleavage. Rocks like these may have been the protolith to carbonate-altered breccias, which will be seen in the following stops.

75.0	1.8	Turn right (east) on bush road.
76.5	1.5	Stop 3.

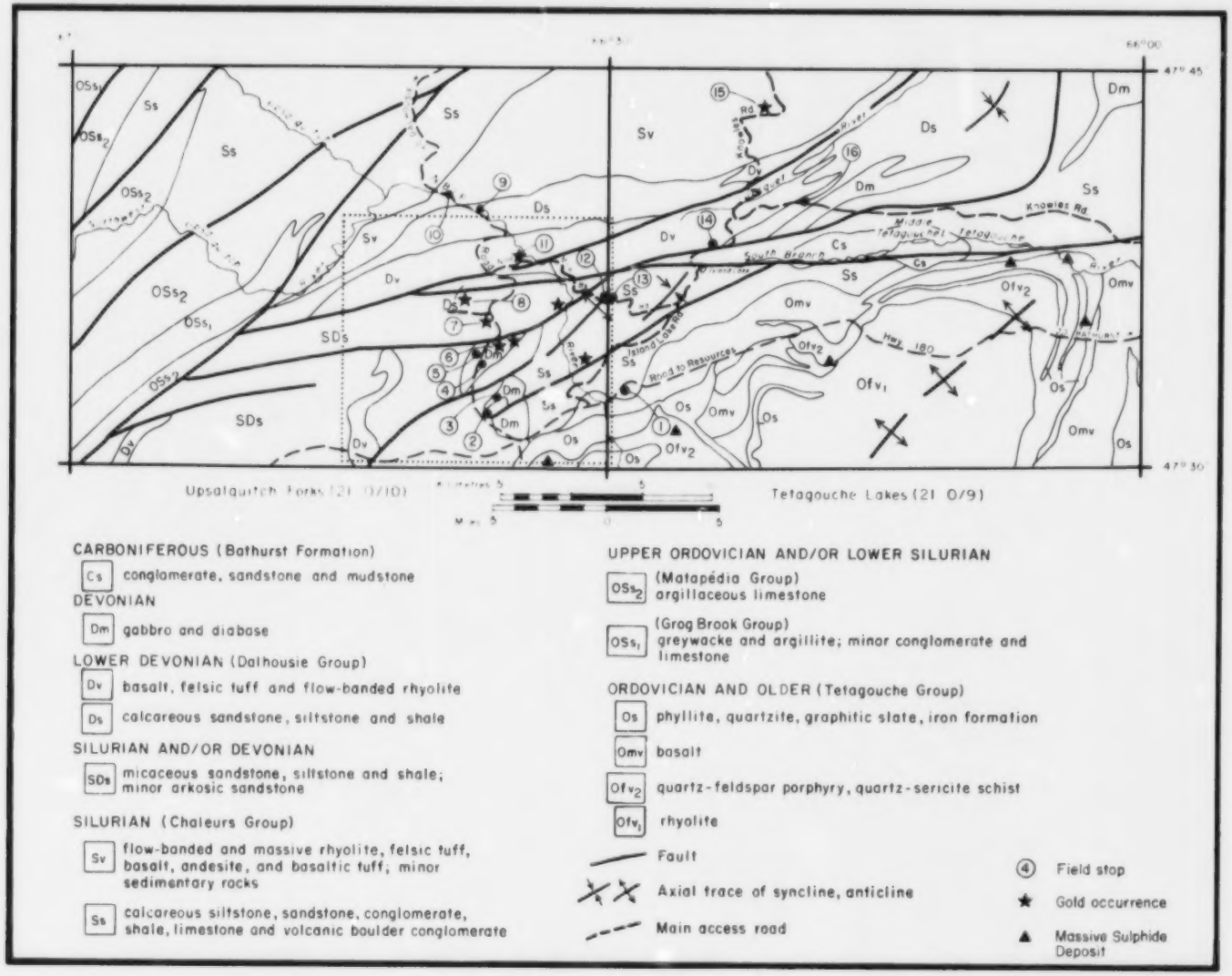
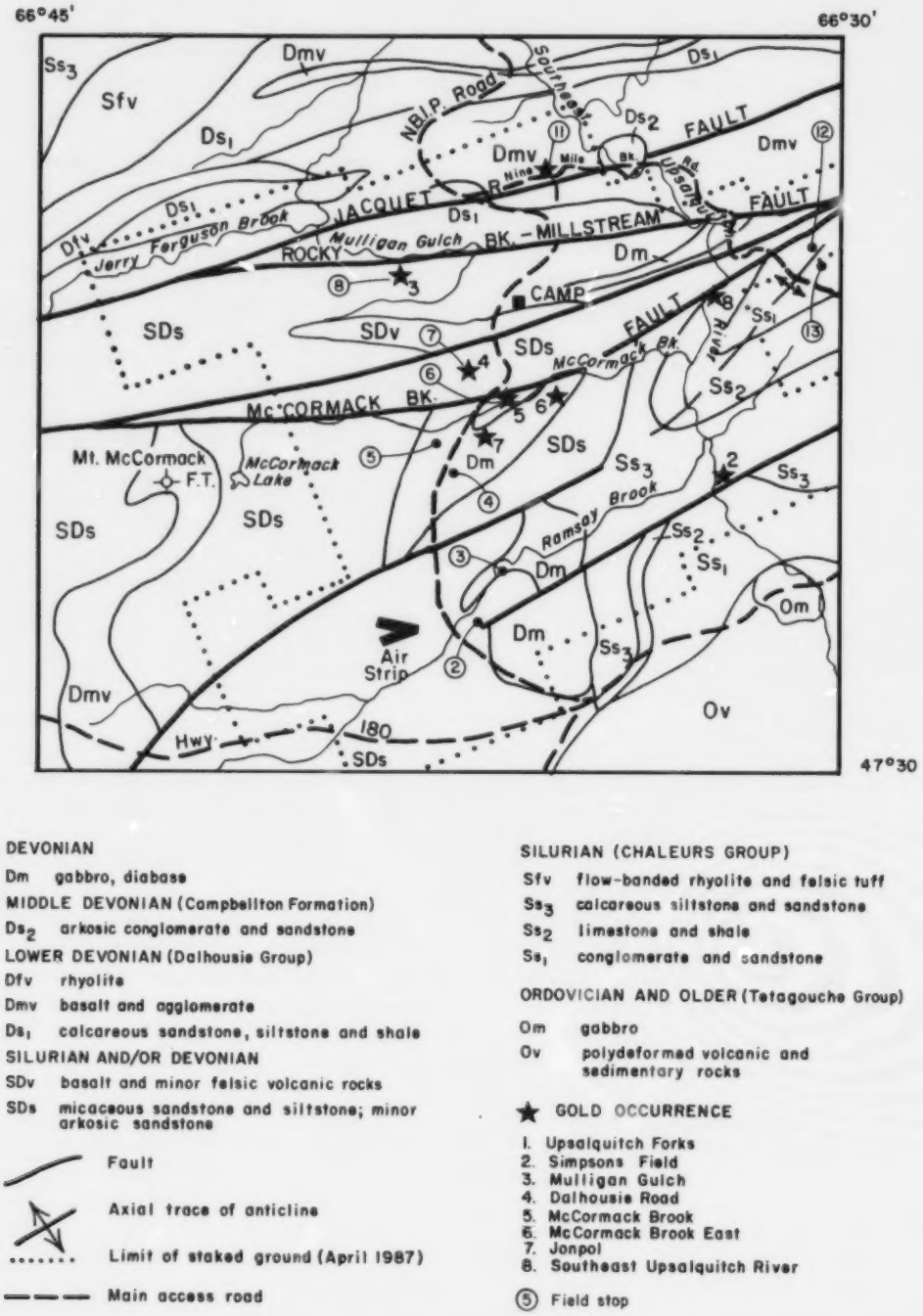

Upsalquitch Forks (21 O/10)
Tetagouche Lakes (21 O/9)
CARBONIFEROUS (Bathurst Formation)
Cs conglomerate, sandstone and mudstone
DEVONIAN
Dm gabbro and diabase
LOWER DEVONIAN (Dalhousie Group)
Dv basalt, felsic tuff and flow-banded rhyolite
Ds calcareous sandstone, siltstone and shale
SILURIAN AND/OR DEVONIAN
SDs micaceous sandstone, siltstone and shale; minor arkosic sandstone
SILURIAN (Chaleurs Group)
Sv flow-banded and massive rhyolite, felsic tuff, basalt, andesite, and basaltic tuff; minor sedimentary rocks
Ss calcareous siltstone, sandstone, conglomerate, shale, limestone and volcanic boulder conglomerate
UPPER ORDOVICIAN AND/OR LOWER SILURIAN
OSs2 (Matapédia Group) argillaceous limestone
OSs1 (Grog Brook Group) greywacke and argillite; minor conglomerate and limestone
ORDOVICIAN AND OLDER (Tetagouche Group)
Os phyllite, quartzite, graphitic slate, iron formation
Omv basalt
Ofv2 quartz-feldspar porphyry, quartz-sericite schist
Ofv1 rhyolite
Fault
Axial trace of syncline, anticline
Main access road
Field stop
Gold occurrence
Massive Sulphide Deposit

FIGURE 7. Geology of Upsalquitch-Jacquet River area with field stops. Dots outline inset Figure 8.



DEVONIAN

Dm gabbro, diabase

MIDDLE DEVONIAN (Campbellton Formation)

Ds_2 arkosic conglomerate and sandstone

LOWER DEVONIAN (Dalhousie Group)

Dfv rhyolite

Dmv basalt and agglomerate

Ds_1 calcareous sandstone, siltstone and shale

SILURIAN AND/OR DEVONIAN

SDv basalt and minor felsic volcanic rocks

SDs micaceous sandstone and siltstone; minor arkosic sandstone

Fault

Axial trace of anticline

Limit of staked ground (April 1987)

Main access road

SILURIAN (CHALEURS GROUP)

Sfv flow-banded rhyolite and felsic tuff

Ss_3 calcareous siltstone and sandstone

Ss_2 limestone and shale

Ss_1 conglomerate and sandstone

ORDOVICIAN AND OLDER (Tetagouche Group)

Om gabbro

Ov polydeformed volcanic and sedimentary rocks

★ GOLD OCCURRENCE

1. Upsalquitch Forks
2. Simpsons Field
3. Mulligan Gulch
4. Dalhousie Road
5. McCormack Brook
6. McCormack Brook East
7. Jonpol
8. Southeast Upsalquitch River

(5) Field stop

FIGURE 8. Detailed geological setting of the gold occurrences in the Upsalquitch area, New Brunswick, showing field stops 2 to 8 and 11 to 13.

STOP 3. Ramsay Brook bridge. The outcrop just before the bridge on the left side of the road is a gabbro with brown-weathering carbonate alteration. The same alteration occurs in outcrops along the bank downstream toward the bend in the brook. Superficially, the rocks look the same, but those near the bend in the brook are brecciated metasediments.

78.0 1.5 Return to NBIP road to Dalhousie. Turn right (north).
81.0 3.0 Stop 4.

STOP 4. Polymictic breccia along NBIP road. Carbonate-altered hydrothermal breccia occurs along the east side of the road. The polymictic nature of this breccia contrasts with the monolithologic character of breccias in subsequent stops, and it is interpreted as brecciated conglomerate.

81.2 1.2 Continue northward along NBIP road. Stop 5.

STOP 5. Hydrothermal breccia and associated intrusive rocks along NBIP Road. Outcrops of carbonate-altered, hydrothermal breccia are associated with altered and unaltered intrusive rocks in the cleared area on the left side of the road. Pyritic, metasedimentary clasts in the breccia range in size from one to several tens of centimetres. Specularite is common in the diabase dyke close to the road.

82.0 0.8 Stop 6.

STOP 6. Altered diorite outcrops along the right side of the road. Fracture control of the brownish coloured carbonate alteration is apparent.

83.6 1.6 Stop 7.

STOP 7. Dalhousie (NBIP) Road showing. This showing, which was discovered by Brent Murphy in 1985, was one of the first gold occurrences found in the Upsalquitch area. Noranda currently holds this property and has kindly provided the geology map and drill-hole section, Figures 9 and 10 respectively.

A bleached, silicified, carbonate-altered dioritic intrusion outcrops along the left side of the road, and contains quartz and quartz-carbonate veins. Grab samples from these veins have yielded up to 10 g/t Au (Table 1). Note that the limestone and siltstone away from the contact of the intrusion are practically unaffected by the alteration, demonstrating that the hydrothermal fluids were magmatically derived. In the drill core, the limestone is strongly silicified in contact with the intrusion (Figure 10).

85.3	1.7	Turn left
88.2	2.9	There is a road to the right just beyond the small stream. Park. Walk in the road about 200 m to where the road forks. Take the left branch and follow it about 100 m until you come to a cleared area. Stop 8.

STOP 8. Mulligan Gulch showing. Most of the cleared area is underlain by reddish coloured feldspar (minor quartz) porphyry with dark grey siltstone exposed at the eastern end. The effects of silicification and minor carbonatization can be seen at the porphyry-siltstone contact. Light to dark grey zones (2-5 m wide) within the porphyry are characterized by argillic and silicic alteration, associated in places with stockwork quartz veining and brecciation. These zones locally contain up to 20% pyrite and/or arsenopyrite. Three 1-3 m wide, northeast-trending, quartz veins have yielded the best gold assays (Table 1).

91.1	2.9	Return to NBIP road. Turn left (north).
103.7	12.6	Bridge over Southeast Upsalquitch River. Turn right at the road just past the bridge.
104.5	0.8	Stop 9.

STOP 9. Porphyritic microgranite at Southeast Upsalquitch River bridge. The large outcrop on the left, by the little brook, is porphyritic microgranite. It contains phenocrysts of feldspar (up to 5 mm) and minor quartz in a microgranitic groundmass. A shear-related, argillic alteration zone can be seen at the end of the outcrop closest to the brook.

105.3	0.8	Return to NBIP road. Turn right.
106.8	1.5	Stop 10.

STOP 10. Flow-banded rhyolite along NBIP road. Reddish coloured rhyolite outcrops on the right side of the road. It is flow-banded and exhibits well-developed flow folds. Like the porphyritic microgranite at the last stop, it contains feldspar (about 1 mm) and minor quartz phenocrysts. Quartz-filled, lithophysal cavities occur locally.

108.3	1.5	Turn around and drive toward Bathurst. Bridge over Southeast Upsalquitch River.
116.7	8.4	Turn left onto Nine Mile Brook road.
118.9	2.2	Stop 11.

STOP 11. Upsalquitch Forks showing. Low relief outcrop along the right side of the road consists of altered to unaltered dioritic rocks that are cut by quartz-calcite-sulphide veins. The northern (downhill) end of the outcrop is strongly sheared (90°) and non-magnetic, whereas the southern (uphill) end is practically undeformed and magnetic. Even though some of the

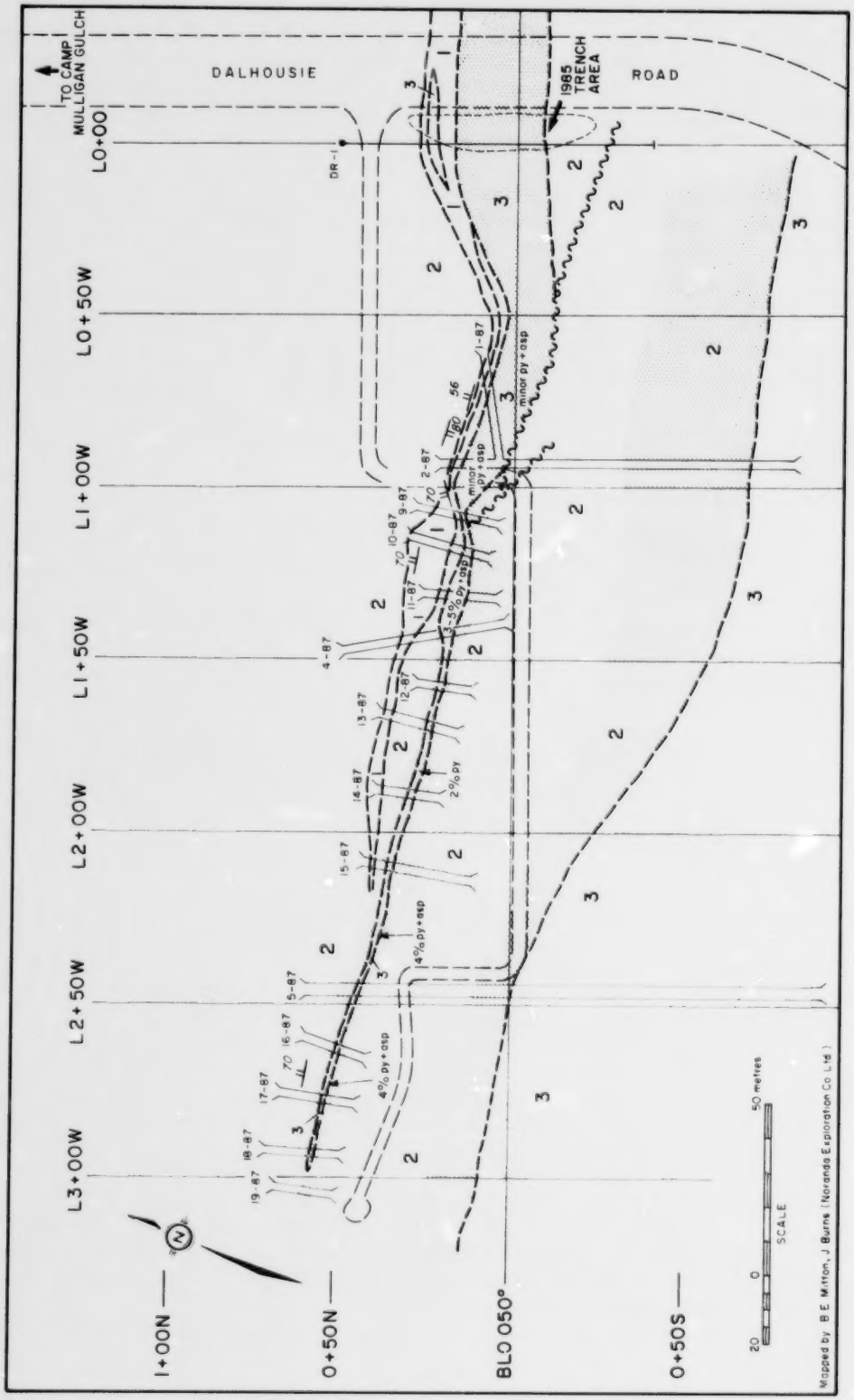


FIGURE 9. Geology of the Dalhousie Road Showing.

LEGEND

DEVONIAN

3 Green diorite

SILURIAN OR DEVONIAN

2 dark grey siltstone and shale

1 limestone; nodular limestone

silicified and carbonatized equivalents

SYMBOLS

70 bedding, tops unknown

geological boundary

fault

DR-1 diamond-drill hole

4-87 trench

Abbreviations:

py = pyrite

asp = arsenopyrite

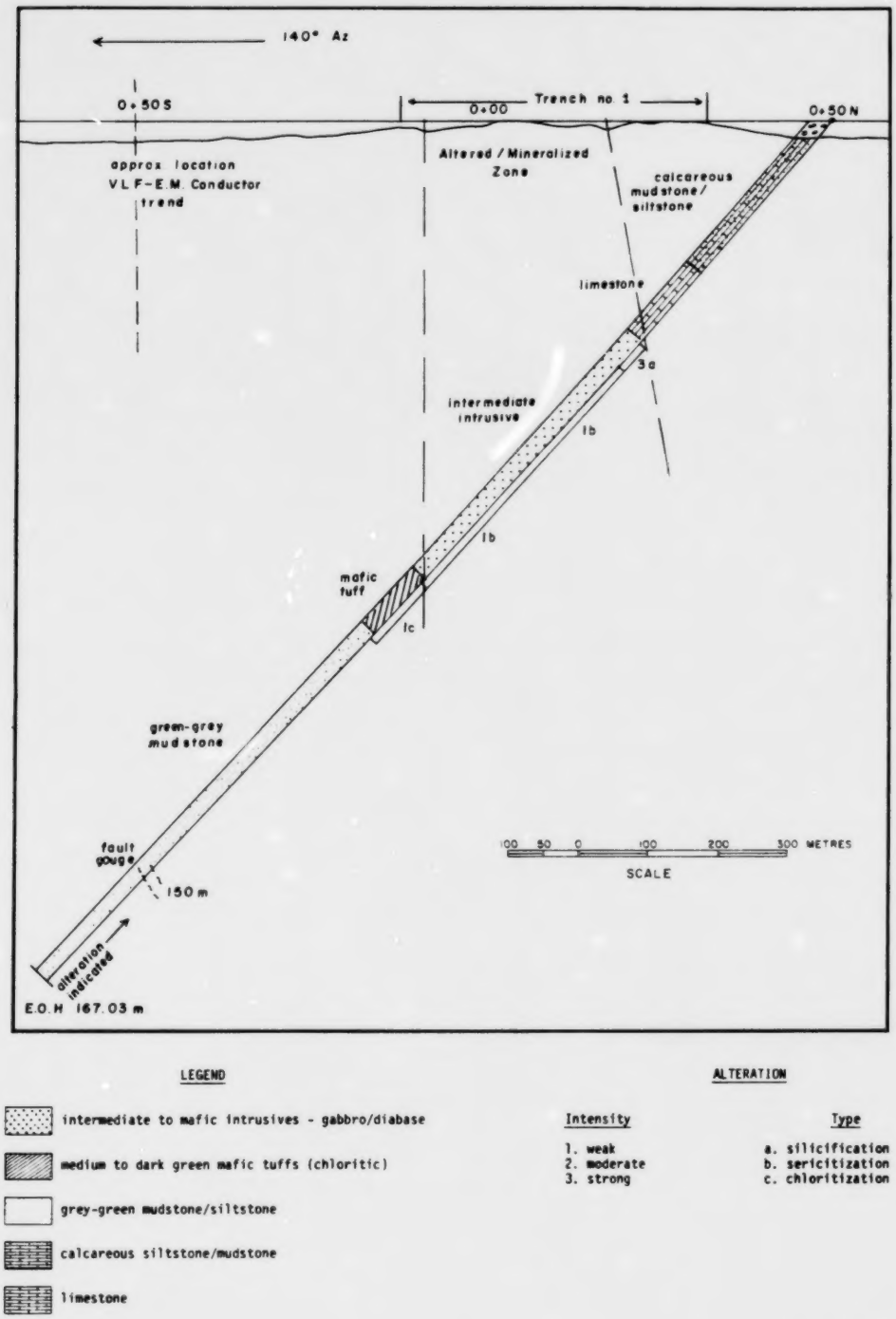


FIGURE 10. Dalhousie Road drill-hole section DR-1.

rocks are reddish coloured, stained slabs show that they are devoid of K-feldspar. The dominant vein orientation is 090-105° with a second set trending 140-155°. Besides pyrite, the veins contain visible chalcopyrite and galena. The highest gold assay from this locality was an initial grab sample that yielded 10 g/t (Table 1). Unlike other occurrences in the area, this one contains a significant amount of copper (up to 8.3%), and the rocks are anomalous in mercury (over 1000 ppb) and bismuth (up to 723 ppm) (Burton 1987).

119.9	1.0	Bridge over the Southeast Upsalquitch River.
126.8	6.9	Three-way junction in the road. Take the middle branch.
127.1	0.3	Stop 12.

STOP 12. Rocky Brook-Millstream fault valley. From this point, one can see widespread iron-carbonate alteration, reflected by the reddish brown colour of the till, in the clear-cut area to the left. The prominent valley is the trace of the Rocky Brook-Millstream Fault.

0.3 127.4 Stop 13.

STOP 13. Chaleurs Group conglomerate. Highly deformed redbeds on the left side of the road have been correlated with the conglomerate and sandstone that was seen at Stop 1 (Davies 1979). Note the stretched clasts in the conglomerate. Behind is a good overview of the valley underlain by the Rocky Brook-Millstream Fault.

136.7	9.3	Island Lake Road. Turn left.
139.7	3.0	Road to Island Lake Canteen. Turn left.
140.5	0.8	Road forks. Take the right-hand branch.
141.0	0.5	The start of an iron-carbonate alteration zone (reddish brown till) that continues for nearly 2 km along the valley of the Rocky Brook-Millstream Fault.
142.1	1.1	Stop 14.

STOP 14. Altered sedimentary rocks near Rocky Brook-Millstream Fault. The outcrop along the left side of the road is composed of iron-carbonate-altered sedimentary rocks. Note the well-defined bedding and its contorted nature. The trace of the Rocky Brook-Millstream fault is located a short distance north of this outcrop.

142.4	0.3	End of iron-carbonate alteration zone.
146.5	4.1	Knowles Road. Turn left.
157.9	11.4	Stop 15.

STOP 15. Rocky Brook prospect. Corona Corporation, formerly Lacana Mining Corporation, has provided the map (Plates 89-10A and 10B) of the area, and details of the geology and geochemistry that are described below.

The property is underlain by rocks that are assigned to the Chaleurs Group (Davies 1979). These rocks have been divided into six units (Plate 89-10A): Units 1 to 4 comprise an apparently conformable sequence of felsic tuff, maroon mudstone, amygdaloidal basalts, and felsic pyroclastics that strikes east-west and dips 25 to 30 degrees southward; Units 5 and 6 are mafic and felsic dykes respectively.

An alteration zone is associated with Unit 2, at surface, and it can be traced for at least 4 km along strike. The zone appears to be tens of metres wide with the strongest alteration (up to 10 m in width) in the siltstone. The zone is structurally controlled because it has a subvertical, or steep, northerly dip. It is characterized by typical epithermal features such as brecciation, strong silicification, and multi-stage veining (vuggy and drusy to chalcedonic quartz). Weak to strong argillic alteration, manifested by white to green colours, is found within and bounding the silicified parts of the zone. Hematite and manganese oxides are abundant near surface. Vuggy white quartz veins with purple fluorite occur in the felsic volcanic rocks.

Soil geochemistry shows that the alteration zone is anomalous in mercury (up to 700 pbb), silver (up to 35 ppm), antimony (up to 65 ppm), and arsenic (up to 700 ppm), particularly in the eastern part of the grid. Analyses for gold gave spotty, erratic values up to 450 ppb.

The discovery showing along the Knowles Road, 100 m east of Rocky Brook, consists of highly altered (silicified and brecciated) hematite- and manganese-rich siltstone. An initial grab sample from this locality yielded 4 g/t Au and 89.6 g/t Ag.

Another showing, the eastern showing, is approximately 800 m east of the discovery showing. It consists of green to buff altered zones, containing brecciated quartz veins, in red siltstone. Chip sampling gave a value of 36.2 g/t Ag over 1.3 m, and composite grab samples yielded values up to 281 g/t Ag. Another composite grab sample from the bulldozer push just to the east gave values of 75.2 g/t Ag and 164 pbb Au.

Three trenches tested the Discovery Zone at Rocky Brook on Lines 0, 0 + 50 E, and 1 + 00 E (Trenches #1 to #3 on Plate 89-10A). All were dug through rhyolite talus that had slumped down the steep hillside to the north. All trenches were chip sampled at about 1 m intervals. The best gold value, 0.996 ppb over 1 m, was obtained from Trench #2, near the south end; the best silver value, 20.7 ppm over 1 m, was at the south end of Trench #3, with a value of 603 ppb Au (over 0.5 m) immediately to the north. A 20 m wide zone in Trench #1 gave silver values in the 3 ppm range with one gold value of 343 ppb over 1 m.

Trenches #4 and #5 were dug on either side of the eastern showing. Both trenches are near Line 9 + 00 E. Values of

959 ppb Au and 221 g/t Ag over 0.7 m and 127 ppb Au and 74.8 g/t Ag over 1.3 m were obtained from the quartz-rich, altered zones in Trench #4. The highest values in Trench #5, 151 ppb Au and 354 g/t Ag over 0.5 m, were found over quartz breccia of the original showing.

The Rocky Brook alteration zone has been tested by 17 diamond-drill holes (see Plate 89-10A for locations). Drill holes #1 to #11 tested the area near the discovery showing; drill holes #12 to #17 tested the area near the eastern showing. All but one of the first eleven drill holes, hole RB-87-10 on Line 5 + 00 W, intersected alteration within red mudstone and felsic tuff, giving a minimum strike length of 600 m for the Discovery Zone. One reported intersection from hole RB-87-2 gave 220.8 g/t Ag and 1.44 g/t Au over 2.2 m.

Drill holes RB-88-12 and RB-88-13 tested silver (up to 35 ppm), mercury (up to 360 ppb), and arsenic (up to 183 ppm) soil anomalies on Line 9 + 00 E. Zones of yellowish green to white argillic alteration, with silicified breccia veins, were intersected and they appear to dip northward at approximately 80°. The drill holes were nearly perpendicular to stratigraphy but intersected the alteration zones at a shallow angle. Maximum true-width of a single alteration zone is about 10 m. Reported intersections from hole RB-88-12 include 207 g/t Ag over 3 m and 332.5 g/t Ag over 1.8 m. Reported intersections from hole Rb-88-13 include 0.77 g/t Au and 150.9 g/t Ag over 2.5 m plus 5.72 g/t Au and 921.6 g/t Ag over 0.3 m.

Retrace the route along Knowles Road to the intersection with Island Lake Road.

169.3	11.4	Bear left (still on Knowles Road).
	2.3	Stop 16.

STOP 16. Dalhousie Group basalt. Basalt on the left side of the road contains well-developed pillows. This pillow basalt can be traced to the northeast for at least 1.6 km.

Continue eastward on this road to Robertville and then take Highway 11 to return to Bathurst.

GOLD OCCURRENCES IN SOUTHERN NEW BRUNSWICK

This part of the field guide describes representative gold occurrences along the Bay of Fundy coast and farther inland in the vicinity of South Oromocto Lake (Figure 11). The area along the Bay of Fundy coast is part of the Avalonian Terrane that extends into northern Nova Scotia and southern Newfoundland (Williams 1978). The Cobequid-Chedabucto Fault System separates the Avalonian Terrane from the Meguma Terrane of southern Nova Scotia. Auriferous quartz-carbonate veins and stockworks are numerous along the intensely deformed southern margin of the Avalonian Terrane (Ruitenberg 1984; Ruitenberg and Fyffe 1988).

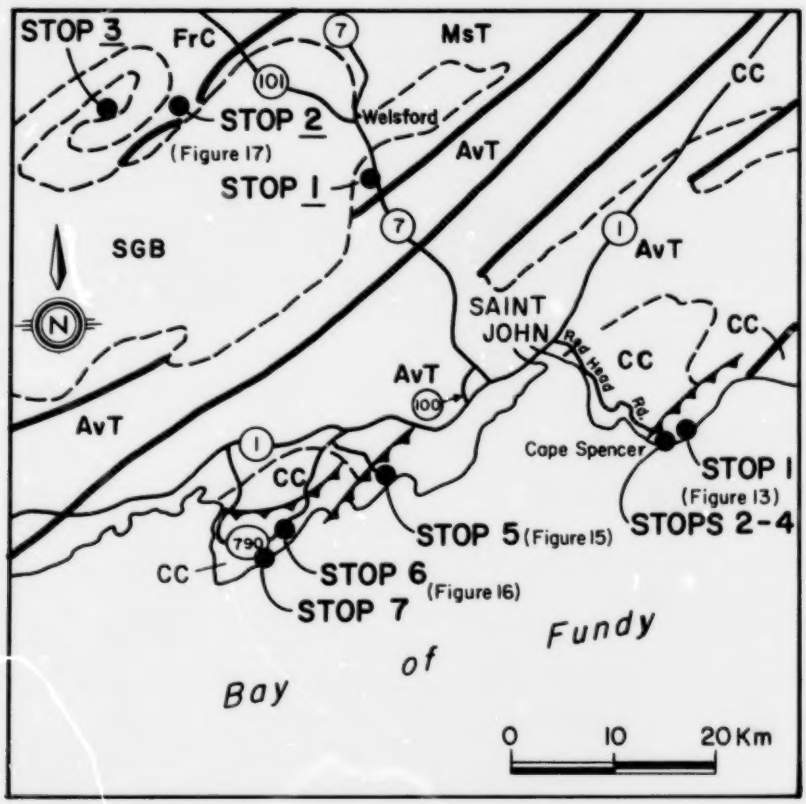


Figure 11. Generalized geology of southern New Brunswick with stop locations: AvT - Avalonian Terrane, MsT - Mascarene Terrane, FrC - Fredericton Cover Sequence, CC - Carboniferous Cover. STOP LOCATIONS - Fundy coast: 1. Mispec Resources; 2.-4. Gordex Mine area; 5. Musquash Harbour; 6. Little Dipper Harbour; 7. Dipper Harbour. South Oromocto Lake area: 1. Nerepis; 2. Shear Mine Prospect; 3. Jimmy Hill.

The deposits are associated with late phases of Hercynian thrusting (Ruitenberg and McCutcheon 1985). The host rocks are Precambrian and Carboniferous sedimentary, volcanic, and intrusive rocks (Ruitenberg et al. 1979).

The Saint George Batholith intrudes Precambrian volcanic and intrusive rocks of the Avalonian Terrane, Silurian volcanic and sedimentary rocks of the Mascarene Terrane that may overlie Avalonian basement, and Silurian sedimentary rocks of the Fredericton Cover Sequence that overlie Ordovician graphitic slate and siltstone of the St. Croix Terrane. The main concentrations of gold occurrences in the South Oromocto Lake area are in shears and fractures that are associated with major fault zones. Most of the occurrences are proximal to mafic-felsic intrusions related to the Saint George Batholith.

FUNDY COAST GOLD MINERALIZATION

Anomalous gold values from the Cape Spencer area were discovered in quartz-carbonate veinlets in the late fifties by Morton Gordon, a prospector from Saint John. Exploration in the area, revived in recent years with the increase in gold prices, has resulted in the discovery of several deposits and showings along the Fundy coast.

Cape Spencer Gold Deposits:

An open-pit mine operated by Gordex Minerals Limited has recovered gold from a low-grade deposit at Cape Spencer. Reported reserves include proven reserves of 606,790 tons at an average 0.073 oz./ton gold and possible reserves of 249,470 tons at an average of 0.066 oz./ton gold (Gardiner 1988). Drill-inferred reserves on an incompletely tested, blind deposit north of the open pit are 330,000 tons averaging 0.26 oz./ton gold (Gordon 1988). Reserves on an adjacent gold deposit of Mispec Resources are unpublished.

Gold deposits at Cape Spencer occur in a thrust and fold belt that extends along the Fundy coast in New Brunswick. The deformation in this belt took place during the latest Carboniferous to earliest Permian Hercynian Orogeny. Hercynian thrusting juxtaposed Precambrian volcanic and sedimentary rocks of the Coldbrook Group, Carboniferous or older arkosic rocks of the Cape Spencer Formation, and quartzose clastic rocks of the Carboniferous Balls Lake and Lancaster formations (Watters 1985; 1986a, b; 1987; 1988).

Stratigraphy: Precambrian rocks in the Cape Spencer area (Figure 12) comprise mafic and felsic volcanic rocks of the Coldbrook Group (Unit 1) and granite and granodiorite (Unit 2). Both Units 1 and 2 are intruded by diabase and/or fine-grained gabbro dykes. Intrusive contacts between the granitoids and the volcanic sequence have been observed east of the map area (Ruitenberg et al. 1979). However, in the map area these contacts are highly sheared and in places faulted. These

Precambrian units constitute a block that is commonly observed in thrust or high-angle fault contact with purple sedimentary rocks of the Cape Spencer Formation (Unit 3).

The Millican Lake Granite (Unit 2) is deformed, altered, and in part mylonitized. A sample at Cape Spencer yielded a zircon date of 625 +/- 15 Ma (Watters 1987). A previous Carboniferous date determined by whole-rock K-Ar method on the same granite at Black River (Ruitenberg 1970) undoubtedly reflects Hercynian overprinting. The granite crops out between Cape Spencer and Black River (Unit 2; Figure 12; Ruitenberg 1984).

The Cape Spencer Formation (Unit 3), which may be as young as Carboniferous or as old as Late Precambrian, consists of a wide variety of sedimentary rocks and tectonized equivalents. Dominant lithologies are fine-grained greyish purple siltstone and slate, coarse-grained polymictic conglomerate, granite-cobble conglomerate, and tectonic breccias (Figure 13). This unit is found in thrust-faulted contact with the Carboniferous Lancaster Formation and with the Precambrian granitoids and volcanic rocks (Figure 14).

Carboniferous rocks include the Balls Lake Formation (Unit 4) and the overlying Lancaster Formation (Unit 5). The Balls Lake Formation is composed mainly of reddish brown quartz-pebble conglomerate, medium-grained sandstone, and minor shale. The Lancaster Formation is mostly composed of grey quartzose sandstone with lesser amounts of grey siltstone, shale, and conglomerate. The two formations commonly interfinger at their contact. Fossil tree trunks at Black River and on the coast northwest of Cape Spencer indicate their Carboniferous age. The Lancaster Formation is in thrust contact with the Cape Spencer Formation on the coast northwest of Cape Spencer (Figures 13 and 14) and at the gate to the Gordex Mine (Stop 2A; Figure 13).

Structure: The sedimentary rocks (Cape Spencer, Balls Lake, and Lancaster formations) and most of the granitoids display a penetrative S_1 cleavage. In the sedimentary rocks, this cleavage is mostly parallel to bedding. Locally, in the finest grained units of the Cape Spencer Formation, S_1 cleavage is parallel to a differentiated layering that can easily be mistaken for bedding. F_1 folds related to the generally shallow, southeast-dipping S_1 cleavage have not been seen at outcrop scale in the Cape Spencer area, but have been described farther northeast (Ruitenberg et al. 1979). However, regional scale northeast-trending, shallow-plunging overturned F_1 folds are interpreted from bedding-cleavage relationships and top indicators within the Carboniferous formations.

A second, spaced crenulation cleavage occurs in the finer grained lithologies of all the sedimentary units. Southeast-dipping (S_{2a}) and northwest-dipping (S_{2b}) cleavages are

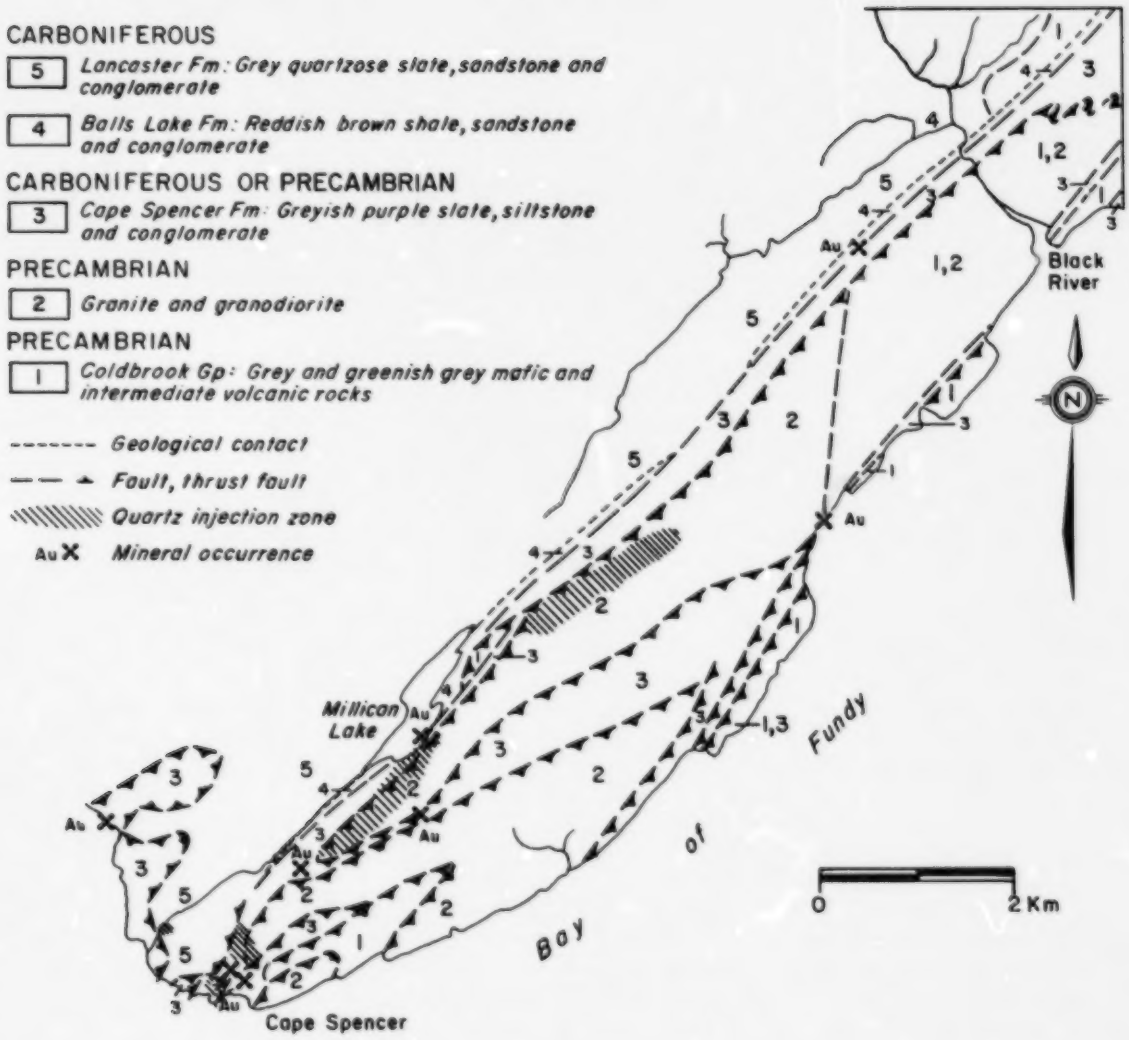


FIGURE 12. Geology of gold-bearing rocks, Cape Spencer area.

associated with shallow-plunging, northeast-trending folds developed over southeast- and northwest-dipping conjugate thrusts, respectively (Watters 1986a, b; Figure 14). Locally, the S_1 and S_2 cleavages in the sedimentary rocks can be correlated with cleavages in the known Precambrian units. A minor D_3 phase of deformation produced local, steep, east-west-striking kink bands and folds with local S_3 cleavage.

A planar set of normal faults with steep southwest dip as well as other less regular, moderately southwest- to southeast-dipping fault zones of breccia and gouge, in places, postdate ore emplacement.

Age of ore deposition: The age of the gold mineralizing event is narrowly bracketed by the age of the youngest strata affected and by the radiometrically-determined age of alteration minerals associated with the gold. Presence in the fossiliferous Lancaster Formation of illite, pyrite, carbonate alteration identical with the alteration in the gold ores (Section A-B; Figure 14) indicates a maximum age of late Carboniferous (Westphalian B) for the event. Illites from the altered ores at Cape Spencer were dated by $^{40}Ar/^{39}Ar$ stepwise heating method giving a minimum age of the event as earliest Permian (Watters 1987).

Gold ores: Generally, gold is found as microscopic grains within pyrite borders, enclosed within pyrite grains, and more commonly, along fractures in pyrite (Stirling 1984). The pyrite, in turn, is developed mainly in illitic alteration haloes adjacent to quartz carbonate veins. Ore zones are hosted by intensely altered and sheared granite and by altered sedimentary rocks of the Cape Spencer Formation. Chalcopyrite is the other most abundant sulphide, and galena and sphalerite are minor constituents.

Ore controls: Structural and chemical controls appear to have governed gold deposition.

Structurally-controlled veining and illitic alteration can be observed near D_2 thrust faults on the Cape Spencer coast and beneath a D_2 thrust sheet of the granite farther inland (Figure 14). Several vein sets associated with this deformation have been distinguished. One set parallels the folded S_1 cleavage, another parallels the S_2 cleavage, and a third set is roughly perpendicular to the D_2 fold axes. The combined primary porosity in coarser grained units and secondary porosity along folded S_1 cleavages and along the D_2 phase structures probably determined the pathway for the mineralizing fluids. En echelon sets of northwest-striking, auriferous quartz-hematite veins that are roughly perpendicular to D_2 fold axes (Ruitenberg and McCutcheon 1985; Figure 13) have, in places, yielded much higher than average gold assays.

Hematite-rich rocks appear to have been favourable hosts for mineralization. Where earlier specularite veins are cut by mineralized quartz-carbonate veins, pyrite has replaced the specularite in a halo around the quartz veins yielding gold-rich pyrite concentrations (Stop 4B). Also, the finest grained unaltered Cape Spencer Formation sedimentary rocks appear to be richer in fine-grained specularite and, where altered, are typically more pyrite-rich than coarse-grained siltstones and sandstones.

Alteration: Two main alteration types can be distinguished. A propylitic alteration that includes chlorite, albite, carbonate, epidote, and quartz ± pyrite is pervasive in the granite, mafic volcanics, and porphyries. It is more intense where they are sheared, especially near major Precambrian block overthrusts (Figure 14). Chloritic alteration of Cape Spencer Formation sedimentary rocks is locally present at these shear contacts.

Alteration zones include a broad halo of carbonate alteration up to tens of metres outward from many of the illite-altered zones. Illitic alteration is associated with the ores and consists mainly of illite, quartz, carbonate, and pyrite. This alteration overprints the propylitic alteration (Figure 13). Possible haloes in the form of quartz stockworks in the granites (Figure 12) might reflect alteration zones below granite overthrusts.

Musquash Harbour Showings:

Gold-bearing quartz veins were first reported in the Musquash Harbour area by Sidwell (1954) and several occurrences have been found in recent years. One of the more interesting recent discoveries is the gold-bearing quartz stockwork exposed in granitic rocks along the west side of Musquash Harbour (Figure 15).

The oldest rocks in the Musquash Harbour area are carbonates and clastics of the Neohelikian Greenhead Group and mafic and felsic volcanic rocks of the Hadrynian Coldbrook Group (Units 1 and 2, Figure 15). The Coldbrook Group is intruded by Precambrian, medium-grained granodiorite, quartz-diorite, and diabase dykes (Unit 3). Unit 3 is mineralogically and texturally similar to the intrusive complex in the Cape Spencer-Black River area. Unit 3 is intruded by fine- to medium-grained porphyritic leucogranite or quartz-eye granite (Unit 4). The oldest Carboniferous rocks are greyish red and light to dark grey algal limestone (Unit 5) of the Middle Viséan Windsor Group (Parleeville Formation, McCutcheon 1981). The Windsor Group is conformably overlain by grey and greyish red quartzose sandstone, mudstone and conglomerate (Unit 6) ranging in age from late Viséan to at least Westphalian C (McCutcheon 1981). The Precambrian intrusive rocks in the Musquash Harbour area are thrust over the Carboniferous strata.

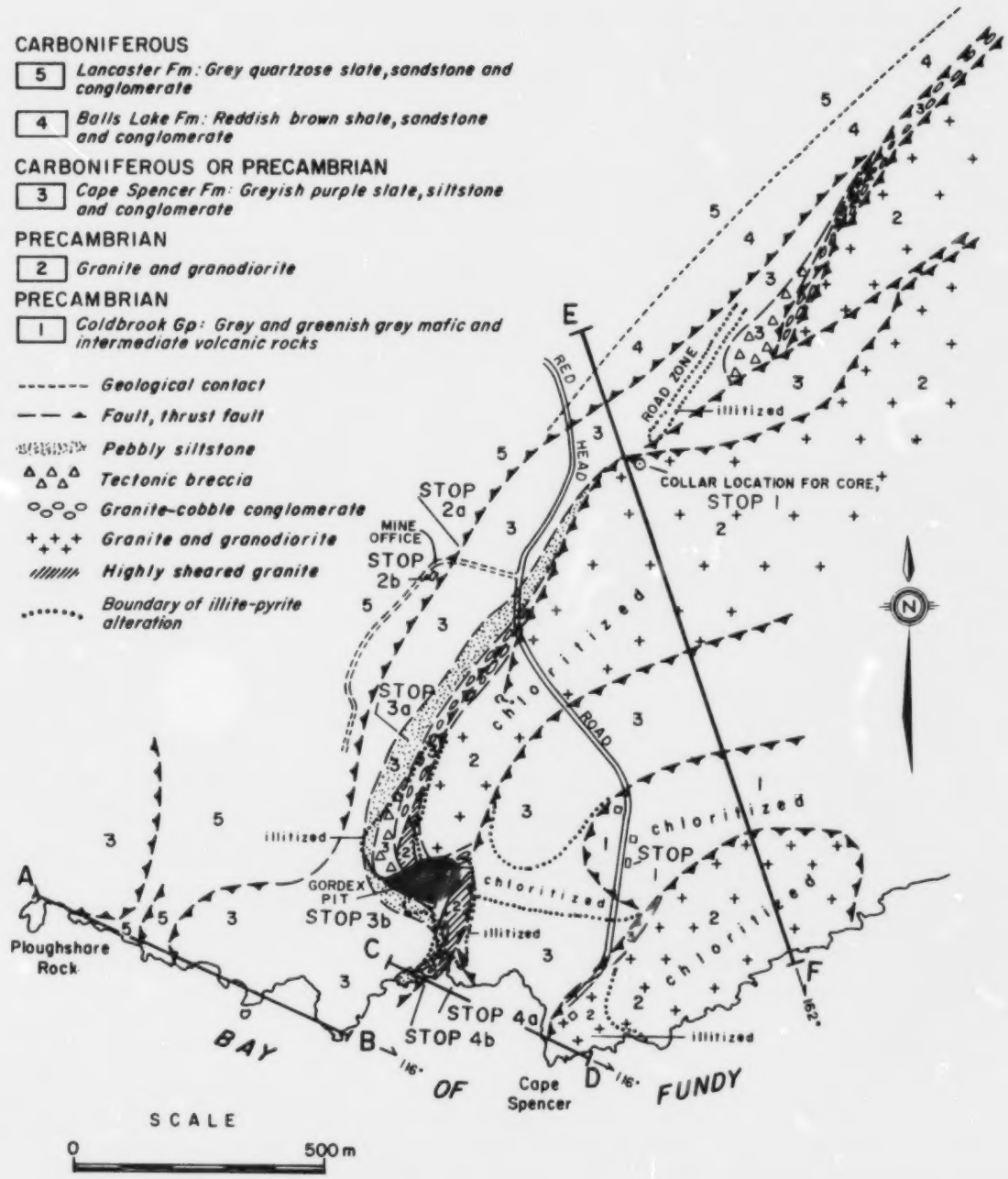


FIGURE 13. Geology in vicinity of gold deposits, Cape Spencer. Location of Stops 1 to 4 and cross-sections A-B, C-D, and E-F is indicated.

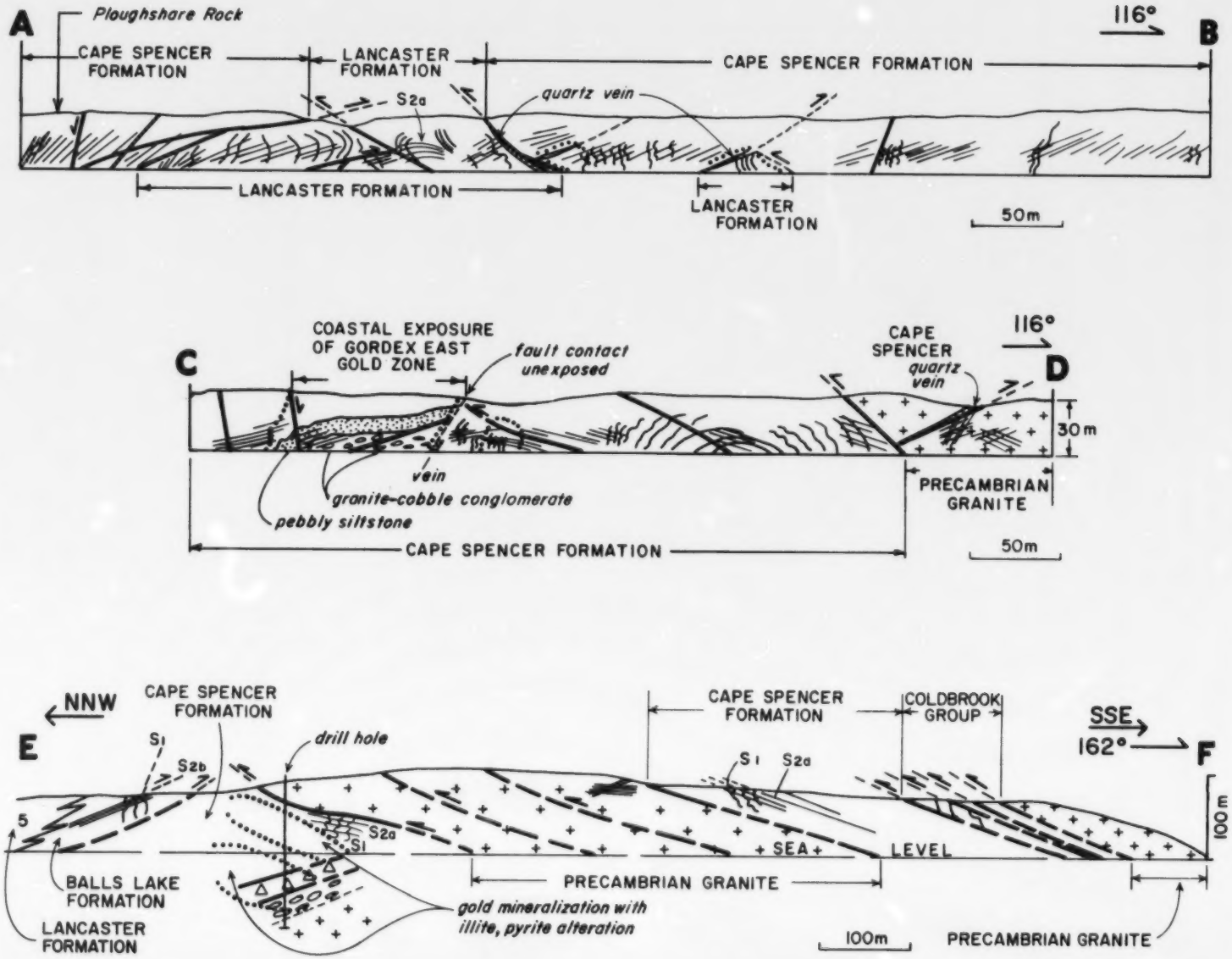


FIGURE 14. Cross-sections A-B, C-D, and E-F in Cape Spencer area. Section lines are located on Figure 13.

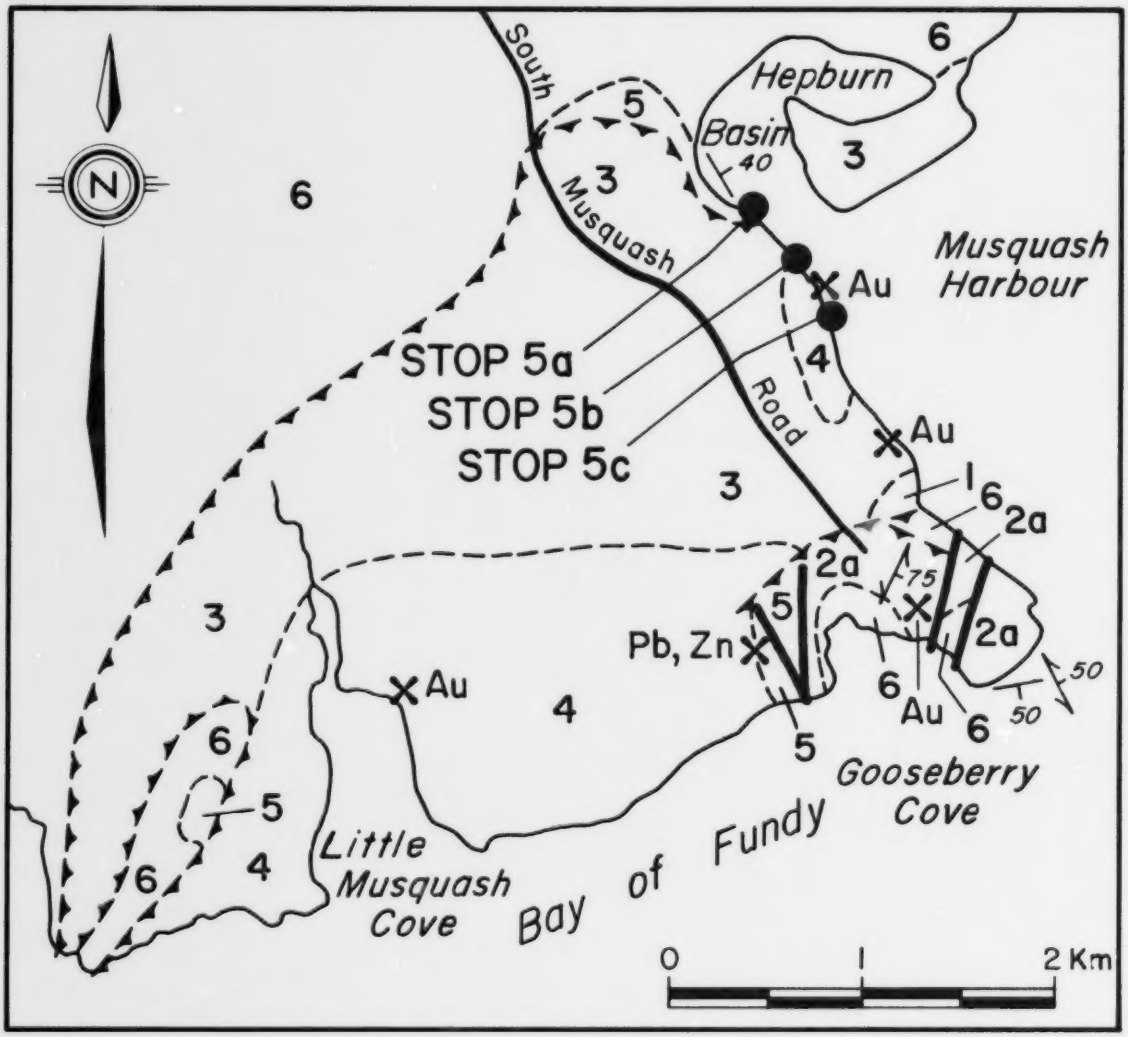


FIGURE 15. Geology of gold-bearing rocks in Musquash Harbour area: 1. Precambrian Greenhead Group carbonates and clastics; 2. Precambrian Coldbrook Group; 2a. Mafic volcanic rocks; 2b. Felsic volcanic rocks; 3. Precambrian or younger granodiorite and quartz-diorite,; 4. Precambrian or younger microgranite and diabase; 5. Carboniferous algal limestone; 6. Carboniferous quartzose sandstone, mudstone, and conglomerate.

In the Musquash Harbour area, gold occurs in quartz veins and stockwork zones. The gold is associated with pyrite +/- chalcopyrite +/- galena +/- sphalerite. The stockworks are within fine- to medium-grained intensely fractured, sericitized, and silicified porphyritic leucogranite. Some veins occur in granodiorite that has been intruded by the leucogranite.

Dipper Harbour Showings:

The oldest rocks in the Dipper Harbour area (Figure 16) are mafic and felsic volcanic rocks of the Coldbrook Group (Unit 1). The Coldbrook Group is intruded by fine- to medium-grained, commonly porphyritic leucogranite (quartz-eye granite) of late Precambrian age (Unit 2).

The Precambrian volcanic rocks and leucogranite are thrust upon Carboniferous clastic sedimentary rocks (Unit 5). A thin sliver of greyish red, quartzose sandstone and mudstone (Unit 3), which occurs locally below the thrust at Chance Harbour, is tentatively correlated with probable Cambrian rocks in the Lorneville area (McCutcheon 1984). Light to dark grey algal limestones (Unit 4), similar to that at Musquash Harbour, are the oldest Carboniferous rocks in the area.

At Little Dipper Harbour (Figure 16), quartz-carbonate veins with chalcopyrite, chalcocite, galena, and gold cut across Carboniferous or older sandstone and conglomerate. The most prominent veins, up to 1 m thick, are situated along the southern limb of a northeast-trending anticline and immediately north of the thrust contact with late Precambrian rhyolite of the Coldbrook Group. A channel sample across the vein assayed 5.25 g/t Au.

At Dipper Harbour, gold-bearing, quartz-hematite veins, up to 16 cm thick, cut intensely altered, late Precambrian rhyolite of the Coldbrook Group. Some older, barren quartz veins in the area are folded, but the gold-bearing quartz-hematite veins have not been affected by this deformation.

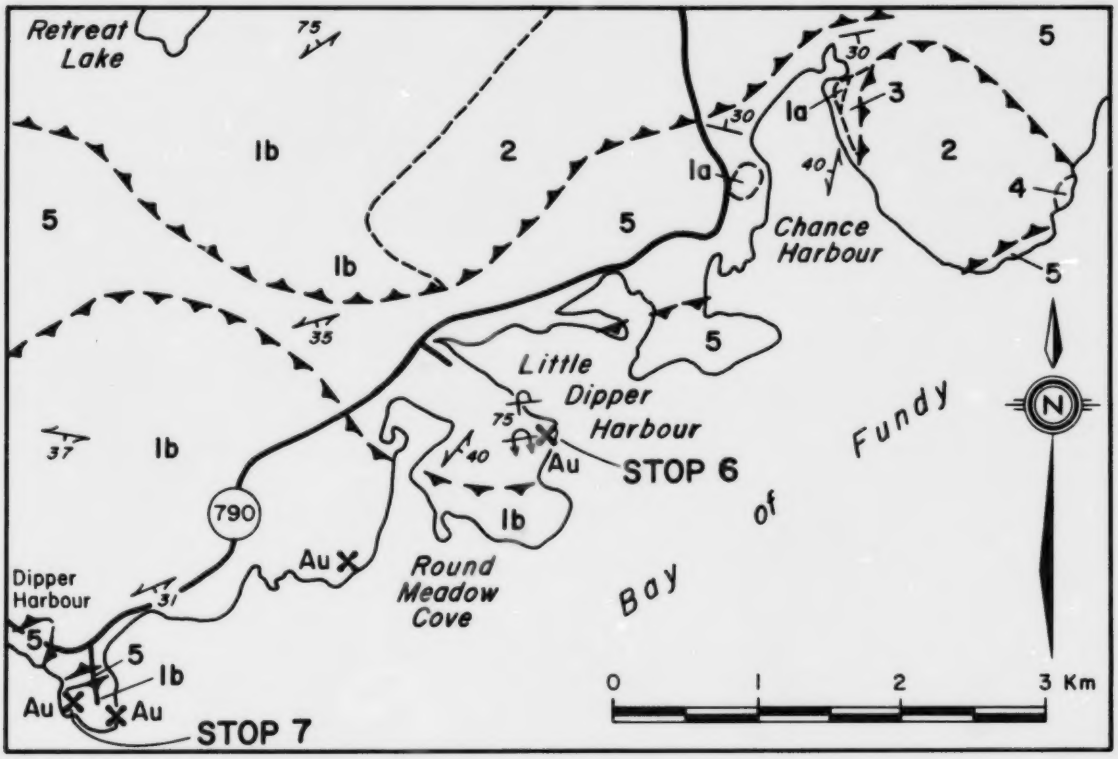


FIGURE 16. Geology of gold-bearing rocks in Dipper Harbour area: 1. Precambrian Coldbrook Group, 1a, mafic volcanic rocks, 1b, felsic volcanic rocks; 2. Precambrian or younger porphyritic leucogranite, diabase; 3. Early Cambrian quartzose sandstone and mudstone, mafic and felsic volcanic rocks; 4. Carboniferous algal limestone; 5. Carboniferous sandstone, mudstone, and conglomerate.

DESCRIPTION OF STOPS ALONG THE FUNDY COAST

Road Log: Follow the Red Head Road from Bayside Drive in Saint John to Mispec Resources field office (Figure 13) - house just before the lighthouse at Cape Spencer (17.0 km - Stop 1).

STOP 1. Mispec Resources field office. Examination of three-dimensional model of Mispec Resources Road Zone deposit. Viewing of drill hole that shows complete sequence from over-thrusted chloritized granite, through mineralized Cape Spencer Formation sedimentary rocks, into tectonic breccia and granite-cobble "conglomerate", and the underlying granite (drill-collar location for this core is shown on Figure 13).

Road Log: Backtrack on same route 0.6 km to the Gordex Mine parking lot (Stops 2 - 4).

STOP 2A. Gate at Gordex Mine. Exposure in ditch shows the faulted contact of the Cape Spencer Formation (fine, purple sedimentary rocks) and Lancaster Formation (grey quartz sandstone).

STOP 2B. Heap-leach pile at Gordex Mine.

STOP 3A. Cobble conglomerate, Gordex pit. Northwest flank of granite near Gordex Pit showing pebbly siltstone unit, illite-altered granite-cobble conglomerate, and chloritized, sheared granite.

STOP 3B. West ore zone, Gordex pit. The Gordex pit exposes part of the west ore zone on the northwest flank of the granite, a barren zone of purple sedimentary rocks, and the east ore zone comprising a lens of sheared granite and sedimentary rock atop unaltered purple sedimentary rocks over the buried southeast flank of the main granite body.

STOP 4A. Quartz-carbonate veins, Fundy coast. Coastal exposures at Gordex showing quartz-carbonate veins mainly along folded S_1 cleavage and illite-pyrite alteration. Here the folded S_1 and the S_2 cleavages are clearly seen below a southeast-dipping thrust. One of the gold-enriched, northwest-striking quartz-hematite veins is exposed here.

STOP 4B. East ore zone, Fundy coast. Eastern ore zone exposure on coast showing intensely sheared granite and granite-cobble conglomerate. Specularite veins with pyrite replacement are present in the sheared units.

Road Log: Follow the Red Head Road back to the intersection with Bayside Drive (34.2 km), turn left on Bayside Drive, turn left on Mount Pleasant Avenue (36.0 km), turn right on Crown Street (39.0 km), turn right on St. Stephen cut-off to Hwy. 1 (40.2 km), follow Hwy. 1 across toll bridge (45.0 km) to Musquash (69.1 km), turn left on Hwy. 790, cross steel bridge

(71.0 km), turn left on South Musquash Road (71.1 km), turn right at Baptist Church (76.6 km), and at 78.8 km walk along path through the woods and cut over to the shore at the head of Musquash Harbour (Stop 5; Figure 15).

STOP 5A. Windsor limestone at Musquash Harbour. At Musquash Harbour, a Middle Viséan limestone exposure of the Windsor Group (Parleeville Formation, McCutcheon 1981) shows a stromatolitic mound flanked by intraformational breccia and wackestone containing plant fossils. Porphyritic microgranite, the host rock for gold occurrences, is farther south along the shore.

STOP 5B. Plutonic rocks at Musquash Harbour. Diabase and fine- to medium-grained porphyritic microgranite (Unit 4) intruding granodiorite and quartz-diorite (Unit 3), respectively.

STOP 5C. Quartz stockwork at Musquash Harbour. Gold-bearing quartz-stockwork zone in fine-grained, intensely fractured, sericitized and silicified porphyritic leucogranite (quartz-eye granite). Gold occurs in similar intensely fractured granite along Little Musquash Cove. A rock-chip geochemical survey conducted by K.D.A. Whaley (1984) revealed highly anomalous amounts of gold in numerous areas within this intensely fractured and altered granite.

Road Log: Return from the Musquash Harbour gold occurrence along the South Musquash Road to the intersection with Hwy. 790 (85.5 km), turn left and follow Hwy. 790 through Chance Harbour and cross bridge at tidal stream (96.0 km), turn left on bush road immediately after bridge, park at old cemetery (96.3 km), and walk along woods road to the shore (Stop 6, Figure 16). During the summer, this woods road can be driven with a half-ton truck or 4-wheel-drive vehicle. From here return to Hwy. 790 (96.6 km), turn left and continue to intersection with woods road to left (111.6 km), follow road until its termination (114.2 km), park and follow foot path to shore (Stop 7, Figure 16).

STOP 6. Quartz-carbonate veins at Little Dipper Harbour. Northwest- and northeast-striking quartz-carbonate veins with chalcopyrite, chalcocite, galena, and gold cut across Carboniferous sandstone and conglomerate at Little Dipper Harbour (Figure 16). The veins cut across the southern limb of a northerly overturned anticline that is well exposed in the coastal section. Bedding tops can be determined from well-developed cross-bedding. This occurrence is immediately north of the thrust contact with Precambrian rhyolite.

STOP 7. Quartz-hematite veins at Dipper Harbour. Northeast-striking quartz-hematite veins cutting across intensely fractured and altered rhyolite of late Precambrian age outcrop at Dipper Harbour. Older folded quartz veins are exposed immediately north of the gold-bearing, quartz-hematite veins.

GOLD MINERALIZATION IN THE SOUTH OROMOCTO LAKE AREA

Numerous gold-bearing structures and veins occur near the contact of the Saint George Batholith in the South Oromocto Lake area. The batholith intrudes a structurally complex region of southwestern New Brunswick that contains a variety of rock types ranging in age from Precambrian to Early Devonian (Figure 17). Gravity studies (Thomas and Willis 1989) confirm that granite emplacement was controlled by deep-seated faults.

Geological Setting:

Map units to the east of the batholith are confined to blocks bounded by northeast-trending faults. The two largest structures, the southeast-dipping Wheaton Brook Fault (high-angle reverse movement) and the Pendar Brook Fault (sense of movement unknown), have associated gold mineralization.

The area south of the Wheaton Brook Fault is underlain by a variably deformed, complex assemblage (Unit 1) of felsic volcanic and sedimentary rocks of the Coldbrook Group, Precambrian granitoids, and Cambrian sedimentary and mafic volcanic rocks of the Saint John Group (Currie 1987, 1988; McCutcheon and Ruitenberg 1987; and McLeod et al. 1988).

The area between the Wheaton Brook and Pendar Brook faults is underlain by conformable Silurian sedimentary rocks of the Queen Brook Formation (Unit 2), and Silurian volcanic and sedimentary rocks of the Long Reach (Unit 3a) and Jones Creek (Unit 3b) formations, respectively (Figure 17). Rocks of Ordovician(?) age (Unit 4) are separated from the Queens Brook Formation by a possible continuation of the Ketchum Brook Fault, which separates similar lithologies to the northeast. The Late Silurian-Devonian Welsford alkali granite complex (Unit 6a) and the Late Devonian Mount Douglas granite (Unit 6b) intrude these rocks. The stratified rocks are deformed by shallow-plunging folds with a locally developed northeast-trending cleavage.

The stratified rocks northwest of the Saint George Batholith have not been mapped in detail, so that precise location of contacts are not known. In the northeast, these rocks are correlated with the Silurian-Devonian Flume Ridge Formation (Unit 5). A pervasive northeast-trending fabric is developed throughout this unit (Figure 17). In the southwest, undivided Ordovician-Silurian sedimentary and volcanic rocks (Unit 4) intervene between the Saint George Batholith and the Flume Ridge Formation. These rocks exhibit a well-developed cleavage in favourable, finer grained lithologies.

The Saint George Batholith, which was emplaced during the waning stages of the Acadian Orogeny, is a large, composite body comprised of several texturally variable phases including granite and leucogranite (Unit 6b), and granodiorite (Unit 6c). The eastern lobe of the batholith, the Mount Douglas Granite, hosts numerous endogranitic Sn-W-bearing sheeted veins.

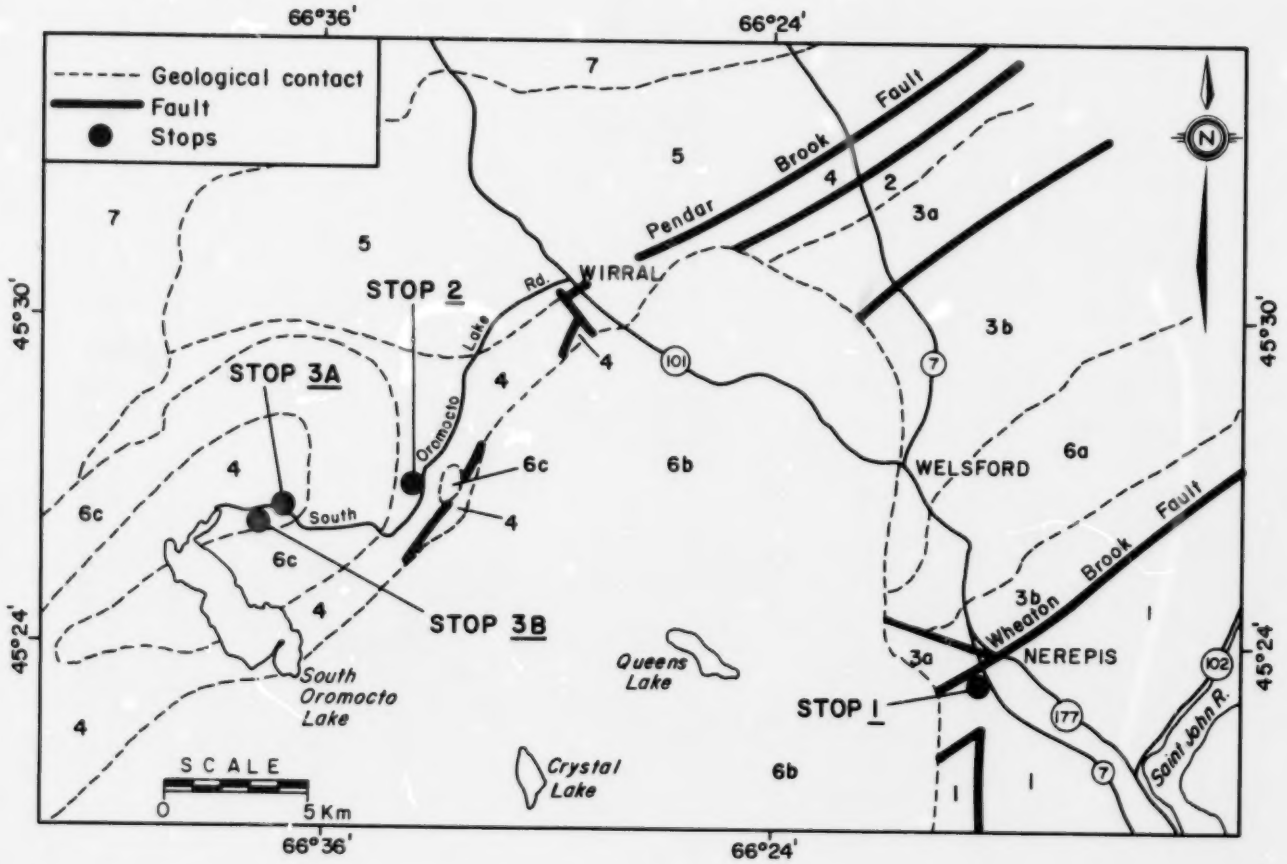


FIGURE 17. General geology and stop locations, South Oromocto Lake area: Avalonian Terrane - 1. Precambrian Coldbrook Group, and Cambrian Saint John Group; Mascarene Terrane - 2. Silurian Queen Brook Formation; 3a. Silurian Long Reach Formation; 3b. Silurian Jones Creek Formation; Fredericton Cover Sequence - 4. Undivided Ordovician-Silurian sedimentary and volcanic rocks; 5. Silurian-Devonian Flume Ridge Formation; Saint George Batholith - 6a. Late Silurian-Devonian Welsford Complex; 6b. Late Devonian Mount Douglas Granite; 6c. Early Devonian Magaguadavic Granite; Mount Pleasant Caldera Complex - 7. Late Devonian and Carboniferous Piskahegan Group.

Gold Showings:

East of the batholith, gold is associated with base-metal sulphides in quartz and quartz-carbonate veins near major fault and shear zones and with a base-metal-tin-gold-bearing skarn deposit. One interesting gold occurrence is exposed in the Nerepis area within 2 km of the granite contact, along strike of the skarn deposit. This indicates that, in addition to structural controls, granite emplacement may have played an important role in mobilizing ore-bearing fluids.

To the northwest, several gold occurrences have been found in Unit 4 near granitic and granodioritic phases of the batholith. Arsenopyrite, pyrite, and low but anomalous assay values of Bi and Sb normally characterize these occurrences. The auriferous occurrences are found either in silicified shear and structural dilatent zones adjacent to granitic rocks or in quartz veins and silicified zones near granodioritic rocks. The former type is undoubtedly related to the Pendar Brook-Ketchum Brook fault zone.

STOP DESCRIPTIONS FOR THE SOUTH OROMOCTO LAKE AREA

Road Log: Return to Hwy. 1 via Hwy. 790, turn right to Saint John, take exit 99 (0.0 km). Proceed toward Highway 7 via Highway 100. At intersection of Highway 7 (2.5 km), turn left and proceed north (23.9 km) to Stop 1, Figures 11 and 17. Continue northward on Hwy. 7 to Hwy. 101 (31.7 km) at Welsford. Turn left, proceed north on Hwy. 101 to Wirral (44.9 km), turn left on paved road (South Oromocto Lake Road) to 53.7 km just past small bridge and walk 200 m west crossing small stream to trenches (Stop 2, Figure 17). Continue along main road to 60.2 km, walk 10 m north of road (Stop 3A, Figure 17). Continue along main road to 60.8 km, walk 500 m south of road (Stop 3B, Figure 17).

STOP 1. Quartz-carbonate veins at Nerepis. This road cut is just south of the Wheaton Brook Fault, at Nerepis, and contains highly sheared felsic volcanic and sedimentary rocks of Precambrian to early Palaeozoic age and numerous Devonian diabase dykes. The gold (up to 0.07 oz./ton over 7 m) is associated with base-metal-sulphide-bearing, steep-dipping, quartz-carbonate veins in sericitized and locally, silicified zones (Whaley 1987). The altered zone trends at 040°, is up to 100 m wide, and extends at least a few hundred metres along strike. The wall rocks contain disseminated pyrite, sphalerite, galena, and chalcopyrite. This occurrence may be an en echelon continuation of the Nerepis base-metal sulphide, tin, gold-bearing skarn deposit situated adjacent to the Saint George Batholith.

STOP 2. Old Shear Mine. The trenches were excavated within a few metres of the "Old Shear Mine" prospect from which gold values of 0.5 oz./ton have been reported. Intercalated pyritiferous, siliceous sedimentary rocks and spotted schist (Unit 4) are exposed in the trenches. Steep-dipping, north-northeast-trending quartz veins exposed in the old pit and in the northernmost trench, are up to 0.5 m wide and contain coarse pyrite, magnetite, and the highest recent gold values (up to 0.28 oz./ton Au and 1.75 oz./ton Ag) (Whaley 1986). Wall rocks are locally silicified and contain, in addition to anomalous gold values, pyrite, arsenopyrite, pyrrhotite, sphalerite, and chalcopyrite. Granodioritic rocks of the Saint George Batholith crop out to the east and west of this locality and probably underlie the occurrence at shallow depths.

Numerous other gold showings have been found in this area. The most significant showing, which contains up to 0.52 oz./ton Au, occurs in a silicified zone northeast of the "Old Shear Mine" near Sand Brook Mountain (Brown 1988).

STOP 3A. Quartz veins near Jimmy Hill. A 10 cm wide quartz vein striking 120° and dipping 80°NE intrudes hornfelsed, pyritiferous sedimentary rocks (Unit 4) just north of grano-

dioritic rocks of the Saint George Batholith, near Jimmy Hill. The vein contains pyrite, pyrrhotite, chalcopyrite, and gold values of 0.11 oz./ton. One hundred and fifty metres to the north, a 10 m wide, highly altered and locally sheared, quartz-feldspar porphyry dyke extends about 1000 m along a 110° strike.

STOP 3B. Quartz veins on South Oromocto Lake Road. In these outcrops, hornfelsed, pyritiferous sediments (Unit 4) are intensely veined by quartz immediately north of granodioritic rocks of the Saint George Batholith. The largest vein has been trenched, and is about 0.5 m wide and 30 m long. The vein strikes 080°, dips shallowly to the south, and is cut by northwest-trending, quartz-filled shears. The vein contains some carbonate, coarse wolframite altered in part to scheelite, bismuthinite, minor molybdenite and 0.17 oz./ton gold. Tourmaline occurs in quartz-veined boulders in this vicinity.

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